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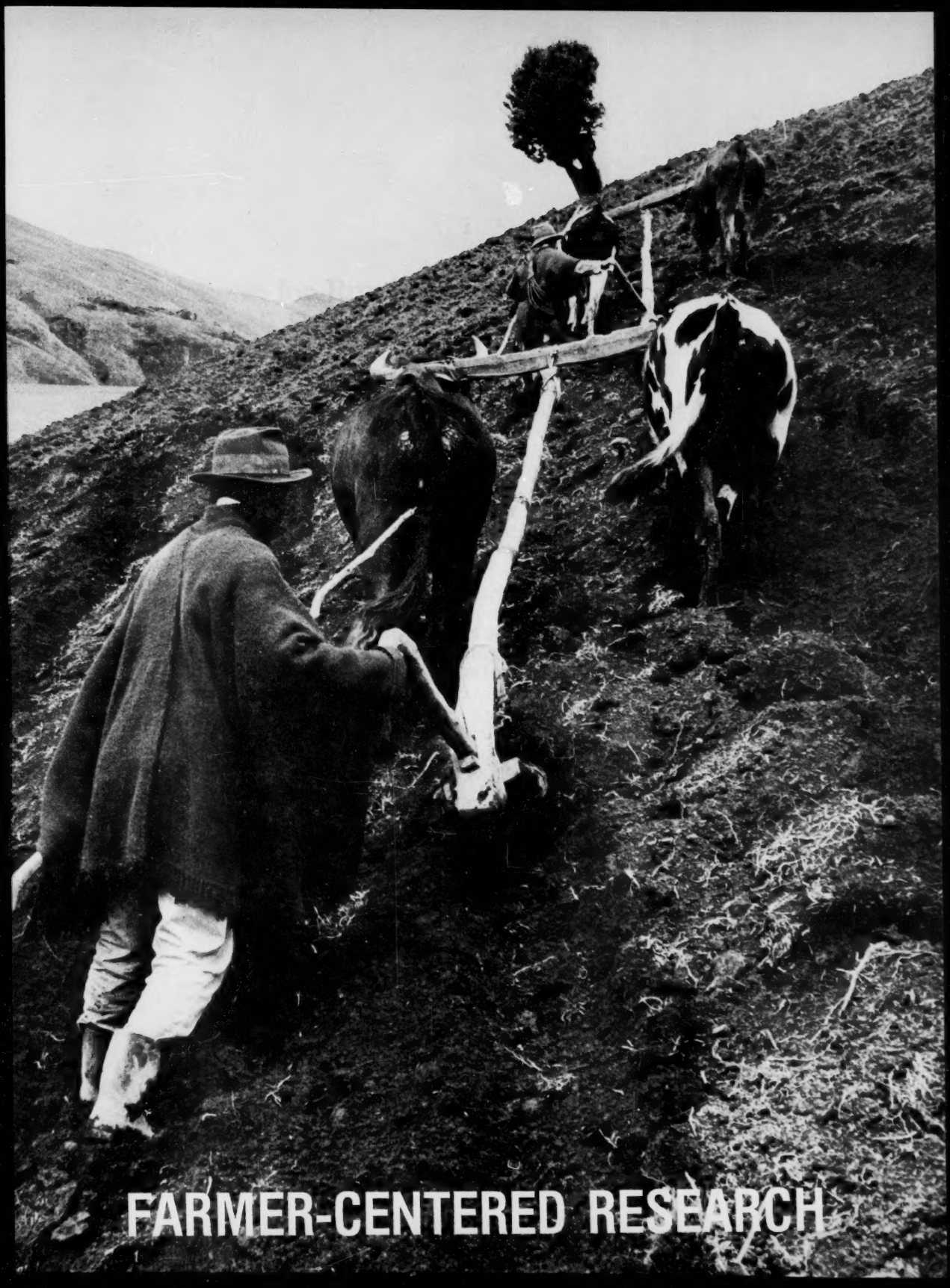

FARMER-CENTERED RESEARCH

SMALL FARMER PLOWING IN THE
ANDES MOUNTAINS IN ECUADOR
(PHOTO: FAO BY P. BOTTS)

A Lesson for Rural Developers: The Small Farmer is a Professional

Robert Chambers

[Unconscious biases exist in the opinions and advice of "professionals" of every kind working on rural development in the developing world. These biases often render programs ineffective. The most difficult thing for an educated expert to accept is that poor farmers may often understand their situations better than he does. The following article examines some of the common biases and sets forth some remedies to aid in overcoming them.]

Self-critical introspection is not a prominent activity in professions concerned with rural development. It can be argued, though, that without such introspection our views of small farmers and their environments are likely to be largely determined by our professional training, the forms of exposure we have to small farmers, and our own environments. We are taught to see the world in certain ways, to look for certain things, to ask certain types of questions. This makes it difficult for us to see the world in other ways, to look for other things, and to ask other types of questions. A medical doctor, an agronomist, an engineer, an economist and a sociologist, visiting the same village, will see and inquire about very different things. They will gain very different, and partial, views of a whole that is seen differently, and more holistically, by the villagers themselves. They will reach different, and sometimes conflicting, opinions about what ought to be done in the name of development.

A first step, then, in trying to understand small farmers and their environments is to become aware that we have professional blinders: that there are things

Robert Chambers is a Fellow at the
Institute of Development Studies,
University of Sussex, U.K.

we do not see, questions we do not ask, and relationships we do not identify. We also have to understand the biases built into the ways in which we are exposed to and carry out inquiries about small farmers and their environments.

Rural development "tourism" (brief rural visits by urban-based professionals) is a very widespread activity. It has interlocking and mutually reinforcing tendencies that direct attention to those who are better off, to the exclusion of those who are worse off. Rural development tourism has many biases:

- *urban:* toward those rural areas near towns. These are usually more prosperous
- *pavement and roadside:* along paved roads, where the better-off people live with the better services
- *regional:* to regions that are more developed rather than less
- *project:* to projects rather than areas without projects
- *elite and large farmer:* toward meeting those who are better off and more powerful, toward the larger and more progressive farmers, and toward farmers rather than the landless
- *male:* toward meeting men rather than women
- *user:* toward meeting users rather than non-users of services (the members of cooperatives, not non-members, etc.)
- *dry season:* toward travel in the dry season after harvest when people are healthier and better fed, rather than during the rains before harvest when the reverse is true
- *irrigation:* toward areas with irrigation rather than those without; and so on.

Any one of these on its own would be serious. Combined they mean that there is a strong systematic bias toward perceiving rural people as being more prosperous and less deprived than they really are, and toward interacting with and learning from those who are better off rather than those who are poorer.

Moreover, the rewards, prestige and promotions in professions face inward, as it were, toward urban and metropolitan centers.

One can ask: which is valued and rewarded more, professionally--research that benefits small and poor farmers more but generates fewer publications, or research that generates more publications but benefits farmers less? Research on crops or animals for the market or for export (coffee, jute, tea or exotic cattle), or on low-status, more subsistence crops or animals (millet, goats, hens, for example), which are important for the poorer people? Work that makes use of indigenous technical knowledge and is carried out in collaboration with farmers as equal colleagues, or work that is based solely on modern scientific knowledge regardless of the on-farm situation and without farmers' participation? Trials (a low-status word?) on farmers' fields, or research (a high-status word?) on agricultural research stations? If the implications of these rhetorical questions are correct, then there are forces restraining agricultural scientists from too close contact with farmers. Like small farmers, agricultural scientists are professionals and rational. They are likely to behave in ways that are rewarding, given their environment--ways that lead to promotion, higher incomes, opportunities for travel and residence in urban centers where there are various conveniences, including good schools for their children. They are then not merely restrained from contact with small and poor farmers; they are drawn away from it.

Some Consequences

Some of the effects of these and other forces that have kept professionals and small farmers apart have been astonishing. One is the long time it has taken in East Africa for the benefits of intercropping to be recognized. It took decades for it to be realized that farmers' "primitive" practices were efficient, and to adapt agricultural research accordingly. In the meantime, there had been many demoralizing years of suboptimal research generating inappropriate advice.

Introspection also leads one to ask how objectives are chosen. Do we have a tendency to fix on one straightforward objective or criterion as a way of simplifying work and thought, and of eliminating awkward "political" or "social" aspects of development? Agricultural literature is replete with books and papers that treat production as though it were the sole and adequate objective of government interventions. Such a view has been challenged: again and again, those who have benefited from agricultural change have been the strong, the powerful, those who were already better off. The poor and less powerful have sometimes gained a little, sometimes gained not at all, and sometimes lost.

Whatever the myths, agricultural research is highly political in its implications, since it affects who gets what in society. Un-

less approaches to research deliberately incorporate equity considerations, the familiar pattern will be repeated. But agricultural scientists may protest that this is none of their business. In the words of the Tom Lehrer song ". . . when the rockets go up, who cares where they come down--that's not my department . . ." And yet, to pursue the metaphor, the choices about what sorts of rockets to build (what sorts of research to carry out) do determine where they are likely to come down--who will gain and who may lose. Research on poor people's food crops will benefit different groups of farmers more than research on a cash crop grown only by the larger farmers, or only by those with irrigation.

Correction of Biases

All this is well known. Part of its relevance to understanding small farmers is the question: understanding *which* small farmers? Professional training, the biases of rural development tourism, and incentive and rewards systems point professionals toward the better-off farmers and away from the poorer and smaller ones.

If agricultural research is to achieve optimal trade-offs between equity and production objectives, then the following reversals appear necessary.

Valuing indigenous technical knowledge. Modern scientific knowledge and the indigenous technical knowledge of rural people are gro-

tesquely unequal in leverage. The former is centralized, and associated with the power and machinery of the state; and those who are its bearers believe in its superiority. The latter, in contrast, is scattered and associated with low-prestige rural life; those who are its bearers may believe it to be inferior. It is difficult for some professionals to accept that they have anything to learn from rural people, or to recognize that there is a parallel system of knowledge to their own which is complementary, that it is usually valid and in some respects superior. The ability of the Hanunoo people in the Philippines on average to name 1,600 plant varieties, 400 more than in a botanical survey, illustrates the point. Rural people often have their own categories and fine discriminations; they often have much detailed knowledge of soils, of plant indicators of fertility, of weather patterns, of pests and weeds, and the like. Unfortunately, many of those who are bearers of modern scientific knowledge have been trained away from being able to learn these different ways of seeing the environment, or to understand the problems and rationality of small farmers. They do not realize that small farmers are professionals too. The challenge is to be able to learn from them, as colleagues.

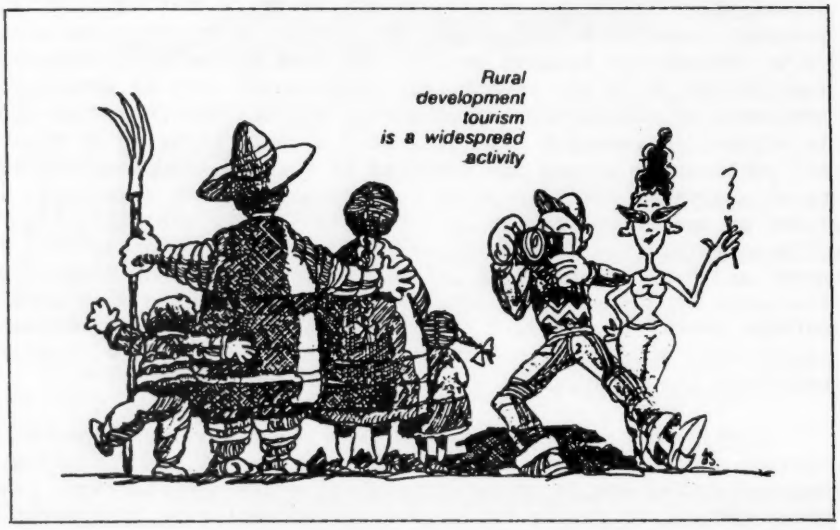
Quick-and-clean versus long-and-dirty. Rural appraisal has tended to have two polar forms--the casual empiricism of rural development tourism, and the long-drawn-out and extensive rural survey. The former has been described as "quick-and-dirty;" and the latter might be described as often "long-and-dirty." The need is to develop methods that are "quick-and-clean," where clean means cost-effective in terms of trade-offs between quantity, accuracy, relevance and actual use of information as against the costs of obtaining it. The reversal required here involves seeing that cost-effectiveness may often (though not always) be best achieved by the quick-and-clean, even though it is not an entirely respectable sort of activity. The dominance of mathematics in education and the reverence for precision in scientific research have generated a whole industry of analysis and publication around the subjects of surveys, sampling and statistical analysis, now reinforced by infatuation with computers, which draws us away from farmers and seems to justify analyzing figures in offices rather than observing crops in fields. We undervalue "judgment" and "experience." It is often possible to know something on the basis of judgment and experience that would take many months, perhaps years, to "prove." The challenge is to develop methods for rapid rural appraisal that combine judgment, experience, indigenous technical knowledge and a new set of methods.

Reversing research station bias. Do precise measurement, controlled conditions, convenience, the location of staff housing, and cost-effectiveness in terms of personal goals (publication, prestige, being noticed by senior colleagues, promotion) have a magnetic effect

in holding agricultural scientists on research stations? For some forms of agricultural research and development there is a valid case for conducting work only under controlled conditions. But these controlled conditions are artificial; they leave out farmers' needs, resources, and problems.

Controlled conditions only are in this sense peculiar and incomplete. Leaving out farmers is a heroic simplification of the environment. Given the many attractions of working on research stations rather than with farmers, one may ask whether there may not be a tendency to rationalize the desirability of on-station work. If the criterion of good research is beneficial impact--benefits to farmers and others in terms of production and equity--might it not be cost-effective for much more work to be conducted with farmers in farmers' conditions?

These three reversals--learning from farmers, using rapid and approximate methods and offsetting research station bias--are reflected in recent work by Michael Collinson with Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) in East Africa and Peter Hildebrand with Instituto de Ciencia y Tecnología Agrícolas (ICTA) Guatemala. Collinson has been shortening the period of survey required to identify research priorities. Hildebrand has developed an ingenious method for rapid appraisal combining agricultural and social scientists in investigating farming situations and leading straight into innovations that are then tested with farmers on their fields.



Unfortunately, there is a tendency for those who engage in and develop these new approaches not to write them up in full detail. It is only in the past few years that describing exploratory or reconnaissance surveys, and quick-and-dirty or quick-and-clean methods, has become a half-respectable activity. It is now, or should be, more than respectable: for these activities are at the frontier of important developments leading to greater cost-effectiveness in agricultural research.

Much of the argument concerns changes in professional values and behavior. But we are faced with a complex system with many interlocking parts--the dominant influence of the agricultural professions in industrialized countries, the policies of editors of journals, urban and research station bias, the curricula of university courses, ideas about respectable and rigorous research methods, disciplinary blinders, belief in the universal superiority of modern scientific knowledge over indigenous technical knowledge, and so on. Combined, these various forces direct attention and effort away from small farmers, away from learning from them and with them, toward the citadels of professional advancement and toward inappropriate research.

Implementing Change

In seeking to change this, some of the obstacles are cognitive. The problem is often the way in which people have been conditioned to perceive and interpret experience. It is difficult enough for a sociologist, for example, to learn to think like an agronomist, let alone for either of them to learn to think like a small farmer. And yet seeing the world in the other person's way--whether the view of another discipline or the multidisciplinary view of small farmers--requires a difficult combination of openness, imagination and humility. Our status and self-esteem are often built on the premise that we have superior knowledge. It then becomes important in public situations for us to display that knowledge, and for the knowledge to be indeed superior.

A recent report listed among the competencies required in young professionals for agricultural research and development, "Ability to handle farming skills *confidently* in front of farmers." This conjures up precisely the problem of the presentation of one's self in such situations: it may be more important to have the greater confidence required to admit ignorance. But even that does not go far enough, for it treats ignorance as something shameful. Rather, ignorance should be accepted positively as an opportunity to learn, whether from another discipline or from small farmers.

The practical problem is how to achieve such an attitude, and the cognitive changes that result. For social and agricultural

scientists concerned with small farmers, four suggestions can be made.

1. Joint field work with professionals in other disciplines. This is a key part of the Hildebrand and CIMMYT approaches. It is fascinating and illuminating to work in field situations with people from other disciplines. One is continuously surprised and intrigued by the things they see, the questions they ask and the inferences they draw. There are few better learning experiences. Numbers should, however, be kept small. For short periods, two people may be ideal. Such work might be a required part of university education and of subsequent specialized training. It should certainly be a crucial part of agricultural research for defined area projects, not just as a learning experience but also in its own right as a means to effective work.

2. Required learning from small farmers. Professional and career development in all fields typically involves periods of further training. In India, for example, this has been organized for senior agricultural experts and administrators. One activity might be investigation of the knowledge of small farmers. For example, glossaries of local terms can be compiled. Among some pastoralists, a listing of words for colors would show a series of very fine discriminations, especially in the browns, which are not captured in other languages. More directly relevant are investigations of names for plants, soils and plant indicators of fertility and microclimates. Farmers' categories, related to their experience and needs, differ from those of scientists, and not only in the Third World: recent work at Cornell has shown that farmers in up-state New York do not find the soil classification of the U.S. Department of Agriculture helpful, and use their own names for soil types. Another example is the calendar system of Bihari farmers in India, which has been found to be more appropriate for describing changes in climate and the sequences of cultivation than the months of the more usual calendar.

One promising approach to learning how small farmers (and professionals) construe their environment is the triads test. This has been used independently by Paul Richards in Sierra Leone with weeds, and by Stuart Hawkins in Australia with dairy sheds. Richards used it to elicit the way in which university botany and geography students, farmers and trainee extension workers saw weeds. In the test or game, four weeds were taken, and respondents presented with groups of three, asked to identify which two were most similar, and then asked to explain the "construct" underlying their choice. This was repeated for different combinations of threes until the latter were exhausted. The university students' construct were taxonomic and morphological. There was no overlap with the farmers' constructs, which were utilitarian. The most startling finding was that the ex-

tension trainees' constructs were close to those of the students and also did not overlap with those of the farmers. The test was enjoyed by the participants, and led to a spontaneous 'seminar' by the trainees on how they would communicate with farmers if their 'scientific' approach to farming made them think in textbook botanical terms rather than in terms of farming utilities. Tentative action proposals for syllabus development and for studying alongside the farmers were beginning to emerge at the end of the period.

Perhaps learning from farmers, using the triads test, might be tried out to see whether it could be a suitable part of future professional training. To require professional staff to learn from farmers in these ways should not be considered demeaning or threatening. On the contrary, it is inherently fascinating to try to understand how other people construe the world. Moreover, where "games" are involved--as with the triads test--the activity is enjoyable as well as intellectually exciting.

3. Learning through games. A further approach is to play specially devised games. Some "green revolution games" have been developed. In these, each player starts with similar resources (finance, family labor, land, water) and makes farming decisions, season by season, in the face of uncertainty about weather, input supply, pests, diseases and the like. A simple computer program, with coefficients derived from actual small-farmer situations and incorporating random contingencies, then presents the outcomes of the decisions. Over a period, players become differentiated: some become wealthy, others landless. But in the process, they are forced to think like small farmers, and to understand their rationality, for example in risk aversion. Such games could become a required part of every course for those, of whatever discipline, who are concerned with agriculture and rural development.

4. Learning by doing. The suggestion likely to be least acceptable to established professionals is that we should go and work at farm tasks with farmers in their fields. To some, this would be totally unacceptable, an affront to dignity. To others, it may appear quite a good idea, but not implementable. To a few, it may commend itself as something to be quietly tried out. And there are some who have done it already. The value of this activity is not to discover the extent to which one's muscles have atrophied, but rather to provide an opportunity for insights and learning. John Hatch's work in Peru is testimony to this. He worked for farmers without pay on condition that they would teach him the task they wanted done.

"The scheme worked beautifully," he reported. "Most small farmers took to their role as teacher very conscientiously. Rather than waiting to respond to my questions, they often volunteered task in-

formation I would never have known enough to inquire about. In fact, most of the information I gathered was gained in this way. Hired laborers often proved excellent instructors as well."

It may be objected that for professionals to work with farmers in their fields would be a waste of time. That is a matter for judgment. Given, however, that Hatch came to the remarkable conclusion that total labor use might be 50 percent higher than that estimated by outsiders, one may ask whether some professionals can afford not to use this approach some of the time. At least there is a case for gaining more experience with it, its costs and benefits, and especially the insights to which it leads.

New Professional Values

The thrust of this article is toward changes in values and behavior: to value learning from and with other disciplines, and especially from and with small farmers; to value equity as well as production; to seek out experiences that are cost-effective, if unconventional, in identifying research priorities; to conduct more research with farmers. It is easier to sit in a room in a rich country and write a little paper about this and the tough things other people should do than it is to be those other people and to do those things.

Perhaps agricultural research that is moving closer to small farmers through defined area projects presents an unusual opportunity. The value systems in agricultural research are international. In the past, this may often have exercised a conservative and inappropriate influence--toward the needs of temperate climates, toward capital intensity, and so on--and much of this may still be enshrined in the curricula of universities all over the world and perpetuated through their graduates. But that same international system could also help to create and invest with prestige a different climate of values, so that national researchers would have more freedom to adopt new practices and turn inappropriate professional values around. If this could occur, some of the beneficiaries would be those national researchers who were at the forefront of pioneering the new methods; but the largest group of beneficiaries should be small farmers whose interests would then be more directly and better served by agricultural research.

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Aiming Agricultural Research at The Needs of Farmers

Donald Winkelmann and Edgardo Moscardi

[Developing the most appropriate technology for the farmers who will use it and offering the most workable recommendations require careful consideration and research on the part of agricultural profesionals. The following article proposes a set of procedures a developing country can follow to find widely useful solutions for representative farmers.]

The Problem

Few farmers in developing countries are following the recommendations of researchers and extension workers. Some claim that farmers are at fault, arguing that preferences based on traditionalism lead farmers to reject unfamiliar technologies. Some point to extension, arguing that the utility of improved technologies has not been demonstrated to the farmers. Others claim that inadequate credit limits farmers' ability to adopt improved technologies. Some emphasize that inputs are not available in a timely way at appropriate prices. Finally, but less frequently, some contend that recommended technologies are often not appropriate for farmers.

Certainly each of these explanations has been valid for some time and place. However, a number of recent experiences have shown that even the poorest farmers--presumably among the most tradition-bound and usually among those with least access to inputs, information and markets--take up certain new technologies while rejecting others. These experiences sug-

The authors are economists with the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT), the International Maize and Wheat Improvement Center in Mexico City.

gest that more attention should be given to the adequacy of recommended technologies. This, in turn, implies that more attention be given to the research systems which develop technologies.

In 1974 CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo) initiated its work to identify effective procedures for developing technologies. The following discussion is based on our interpretation of experiences in this program. The procedures which have emerged are now being tried in several national maize and wheat programs. They emphasize identifying the production problems of representative farmers, and integrating the critical dimensions of their decision-making into research on new technologies. This concentration on research does not imply that the other issues mentioned earlier are not important; they are. But research is CIMMYT's chief activity.

Characteristics of Useful Technologies

The utility of technologies can be judged from two related perspectives: that of the farmers, and that of the larger society. In most cases, to be satisfactory from society's standpoint, technologies must be judged useful by farmers.

In most developing countries, choices among alternative technologies are left to farmers. Two related impressions about farmers are widely held: (1) Farmers are purposeful in their behavior, seeking to obtain incomes and to avoid risks; they are sensitive to the nuances of their environment; and they are reasonably efficient in managing the resources at their disposal. (2) While farmers' choices among alternative technologies are influenced by a host of variables, it is biological and economic forces that dominate those choices. Based on a series of CIMMYT-sponsored country studies examining factors influencing the adoption of new maize and wheat technologies (essentially improved varieties and higher rates of fertilization) we concluded that:

> ". . . the most persuasive explanation of why some farmers don't adopt new varieties and fertilizer while others do is that the expected increase in yield for some farmers is small or nil, while for others it is significant, due to differences (sometimes subtle) in soils, climate, water availability or other biological factors."

These studies and a reading of the studies done by others led to the conclusion that, while other variables might have a limited influence on choices among alternative technologies, income and risk are prominent farmer concerns; and these variables are strongly influenced by the natural and economic circumstances of the particular farmers making the choices. Hence, our emphasis is on these factors.

With this view of farmers, technologies which will be widely used must be consistent with farmers' natural and economic circumstances, and must promise improved incomes while keeping risks within reasonable bounds. Technologies which do not meet these standards will not be widely adopted.

The utility of technologies can also be judged from the standpoint of a nation's goals. National decision makers will want patterns of adoption to have consequences, e.g. for income distribution among producers or for the distribution of benefits among consumers, which are in accord with national goals. Given this concern, those responsible for national policy should not be indifferent toward alternative technologies and, consequently, toward alternative lines of research aimed at forging improved technologies.

Methods for Developing Useful Technologies

Orientation. Four points should be made before initiating a brief description of our procedures for developing useful technologies:

1. We are concentrating on that research whose results are intended for near or intermediate term application, e.g. fertilizer research or plant breeding. We are less concerned with basic or exploratory research destined to be applicable in the long run.

2. The entire process features collaborative research among biological scientists and economists. With farmers sensitive to both natural and economic forces, the formulation of technologies requires the same sensitivity. This is not commonly found in a single scientific discipline and even less in a single individual. In the partnership we envision, the biological scientist contributes his knowledge of the interaction among plants, insects, and diseases and their environment, while the economist brings an awareness of the influence on farmer decision-making of other opportunities for employing his resources and of markets for products and inputs. Beyond this, for issues relevant to policy makers, biological scientists have clearer perceptions of what is feasible through research, while economists have the advantage in sorting out the implications of the adoption of alternative technologies. Each, then, contributes elements which are crucial in the formulation of technologies consistent with the needs of representative farmers and with national goals. This collaboration is a hallmark of the procedures being described.

3. We are concerned here with formulating technologies for a single crop, or for that crop as part of a mixture. We are not discussing full-scale farming systems research.

4. The procedures aim at useful but not necessarily "optimal" technologies. After all, if each farmer responds to his own natural and economic circumstances then, as these differ among farmers, each could need a different "optimum" technology. Satisfying all such demands is clearly beyond the capacity of any national research system. In place of "optimums" we seek to forge good approximations, technologies which promise more incomes with acceptable risks to representative farmers. We expect that, after adoption, each farmer will adjust the recommended practices to fit his own particular circumstances. This expectation is entirely consistent with experience, e.g. the increasing use of fertilizer on HYV (high yielding variety) wheats in India's Punjab and in Mexico's Yaqui Valley. Moreover, this stance relieves the researcher of the costly impression that he must be precise in *framing* recommendations. The researcher must be precise in his research, of course, but his recommendations are most useful when formulated as good approximations for a large number of potential users.

In brief, then, the procedures rest on collaborative research destined for early application, treat a single crop or mixture, and promise useful but not necessarily "optimal" technologies. There is an additional caveat. We recognize that the effectiveness of agricultural research is limited by shortages of physical and human capital, by nettlesome work rules, and by other constraints as well as by the limitations mentioned in our introduction. Even so, research is being done, technologies are being recommended, and farmers are following some recommendations but rejecting most. Hence, it is appropriate to question the methods used in ongoing applied research, and to explore new formats for its undertaking.

Integrating entities. A distinguishing feature of the process described in the following paragraphs is its emphasis on representative farmers as its primary clients. In our view, this represents a significant shift for many countries in the orientation of their agricultural research. And what are the dimensions of this shift?

Much agricultural research in developing countries is concentrated on problems emphasized by professional disciplines and guided

by their standards. This is entirely consistent with the training of most active agricultural researchers and with the incentives which orient their efforts. It is also consistent with the precedents followed in developed countries where technological change has contributed to rapid increases in yields and reductions in production costs. Why, then, with the system featuring professional peers as primary clients apparently working so well in developed countries, is there a shift in emphasis to farmers as primary clients?

We believe such a change will make agricultural research in *developing* countries even more effective. This conviction emerges from our interpretation of the process which links research to practice in *developed* countries. What is most emphasized in the usual statements on this process is the research of the publicly supported institutions. What is emphasized too little is the important role of entities which mediate between this research and the farmer, which integrate research results into effective technologies for farmers. In some cases the mediators are private agribusiness companies, in others public organizations; usually there is a complex of different types.

These mediating entities are not well established in developing countries. Moreover, the incentives of developing-country public institutions do not encourage the researcher to play an integrative role. On the contrary, incentives tend to accent professional contributions--measured by the timely and lucid publication of research results, the contribution to professional organizations, and the training of others in the litany of the discipline. Furthermore, work rules seemingly conspire against anything done off experiment stations. The result is that research is often more attuned to the problems of the profession than to those of representative farmers, and the resulting recommendations are often irrelevant to their needs. It is the absence of this critical integrating activity which underlies our belief that there is scope for making research systems more effective.

Recommended Procedures

We turn now to a brief description of the procedures we have been developing. Their function is to orient the competence of researchers towards the needs of farmers, bridging the gap between research and practice.

Identifying relevant farmers. Natural circumstances in most countries are usually sufficiently variable that several technologies will be needed for a given crop or crop mixture. Moreover, even farmers operating under essentially uniform natural circumstances

might well confront such differing economic circumstances as to need different technologies for a given crop. But it is unlikely that the research resources of a small developing country are sufficient to meet all such demands simultaneously, even for a single crop. The first step, then, in organizing research is to identify the farmers for whom technologies are to be formulated.

The process is expeditiously handled by grouping environments with similar ecologies. This insures that the crop or mixture in question reacts roughly in the same way and confronts roughly the same challenges in all parts of a particular environment, but behaves differently in important ways in other environments. A first grouping can usually be done on the basis of the experience of informed biological scientists and economists working with secondary data on area, yield, soils, weather, elevations, and demography; all this should be complemented by the observations of merchants specializing in the crop.

The next step is to roughly characterize the environments in terms of information which may be important to agricultural policy, e.g. area in the crop, production levels, number of farmers, distribution of farm size, relative importance of the crop, exportable surpluses. Combing this information with researchers' impressions of the potential for improving technologies is usually sufficient to permit a first rough ordering of the environments in terms of national goals.

In Ecuador this procedure was followed to identify five environments in which farmers produce maize. It was inferred from policy statements that the government was accenting the incomes of low-income farmers. For each environment the area in maize, maize as a proportion of total cropland, average farm size and yields were estimated. The zone with the smallest farms and the heaviest reliance on maize also had one of the largest areas in maize, and biological scientists ranked it high in terms of the potential for establishing improved technologies. This congruence will not always occur, so the rankings will often have a degree of arbitrariness, becoming even more arbitrary as government goals are less clearly stated and as impressions about research potential are more probabilistic.

Identifying farmers' circumstances. While secondary data are adequate to frame general impressions, they are rarely sufficiently detailed to orient research on improved technology. Such detail requires first-hand knowledge of circumstances and problems. We advocate two related sets of activities for acquiring that first-hand information. Given the scarcity of research resources, these are concentrated on the environments assigned the highest priorities.

The first of the activities is exploratory survey work in the environments for which technology is to be developed. This will include informal but organized discussions with farmers, merchants and others familiar with the environment. The effort involves both discussion and observation, and focuses on production practices and problems, markets for production and inputs, and important competing activities. Secondary data, the knowledge of researchers, and the results of the exploratory survey are then combined to describe tentative recommendation "domains" (i.e. sets of farmers whose natural and economic circumstances are sufficiently similar so that a given technology would be relevant to each farmer within a domain.)

The second activity starts with the same sources of information plus the insights derived from the exploratory survey, then proceeding to a formal survey. The information and insights are integrated into questionnaires, which are then administered to a random sample of farmers from each tentative recommendation domain. While each questionnaire is focused on issues critical to the farmer, the farm and to the crop or crop mixture of primary concern, it also includes other activities--other crops, livestock, non-agricultural activities or non-farm activities--which impinge in important ways on the crop or mixture under study.

These surveys, especially the formal survey, serve to identify characteristics of representative farmers, e.g. farm size, common implements, typical rotations, critical periods, and access to inputs. They permit description of practices currently employed--levels, types and dates associated with each activity--by representative farmers. They provide information for establishing the representative farmer's perception of major problems affecting the crop or mixture under study. Finally, the survey data also allow for refinement of the description of recommendation domains.

The procedure starts, then, by grouping farmers into essentially homogeneous natural environments. It then orders these environments in terms of national goals, assesses farmers' circumstances, establishes groups of farmers in terms of natural and economic characteristics and of national goals, and makes specific the circumstances of representative farmers for each important crop.

Returning to the example of Ecuador, surveys there indicated that the environment assigned the highest priority contained three different sets of farmers based on natural factors. The three emerged from insect patterns and access to irrigation. The insect patterns, in turn, were closely related to altitude. Some differences in economic circumstances appeared, e.g. farm size and access to inputs; for virtually all farmers in each group, however, these differences were slight. The remaining ungrouped farmers were few and small in pro-

portion to the total area given over to maize. So, no additional recommendation domains were formed because of economic circumstances. For each domain the survey data were used to characterize the circumstances of the representative farmer.

While data on farmer circumstances are gathered primarily to orient research, experience shows that an immediate sifting of the information for policy implications might also be profitable. For example, one maize study showed that a supposedly effective system for distributing inputs was falling far short of meeting farmer requirements for insecticides. The problem uncovered, policy makers could move to clear it up.

The perceptions of farmers and merchants, the knowledge of scientists and the information derived from surveys are then combined to reveal factors significantly limiting the production of representative farmers. As with the earlier activities, data analysis requires the joint participation of biological scientists and economists. The research itself is undertaken on experiment stations and on the fields of representative farmers.

Organizing experimentation. Some of the limitations identified will require research under carefully controlled conditions. This is usually best done on experiment stations. Its benefits often will not be realized in the near term and its results must be tested under the conditions of relevant representative farmers.

Survey work in one Andean region of Peru showed the importance of leaf diseases in maize. With the importance of the disease established, maize breeders began to screen their own plant material and sought promising materials from others to screen for resistance to this disease. In another Andean region, survey work uncovered a farmer demand for a shorter-season variety with good stalk strength. Maize breeders are now recombining shorter-season plants with those having good stalk strength and proper grain type. And why good stalk strength? Because surveys disclosed that the representative farmer grows climbing beans with his maize, and short season varieties were unable to carry the weight of the beans. These problems and opportunities were uncovered through on-farm research involving surveys and experimentation.

On-farm experimentation. The on-farm trials are initiated with "best-bet" strategies based on the experience of researchers and farmers' perceptions. At each critical period in the life of the crop or mixture, farmers and researchers come together around the crop to assess the adequacy of the strategies. Information from the trials flows to the experiment station, signaling new problems, and to trials in succeeding years. Each year information from experiment

station trials is assessed for its relevance to the problems judged most critical.

Three classes of on-farm trials are advocated: yes-no trials, how-much trials, and verification trials. The yes-no trials are designed to look at major effects and first order interactions of the factors thought to be most critical in limiting production. Factorial designs are the mainstay of these trials and these feature two levels of the inputs or practices being examined, one at current farmer levels and the other at a significantly higher level. The how-much trials are designed to identify levels at which income-seeking, risk-averting farmers might want to employ inputs or practices detected as limiting in the yes-no trials.

In developing improved technologies there are always questions regarding how many factors can be changed at one time, to what degree input use can be changed, and at what level those factors not being changed should be set. For on-farm experiments, attention should be concentrated on only three or four factors at a time. Most evidence indicates that farmers tend to make only a few changes at a time, concentrating on those with the highest payoffs; so research can be concentrated on a limited number of factors rather than aiming at all potential changes in one fell swoop. Regarding the levels of input use, profit and risk considerations require that rates of return on purchased inputs be quite high, i.e. probably higher than the apparent cost of capital. This could suggest less intensive use than might be thought desirable by yield-maximizing biologists or profit-maximizing economists. Decisions on how much less can be approximated with farmers during research and verification trials.

Finally, we believe that the non-experimental factors, those which were not part of the yes-no trials, are best set to match practices followed by representative farmers. These variables are not important in determining yields or costs--or else they would be among the experimental variables--so they can be set at low-cost rather than at high-cost levels.

Each year, best-bet strategies must be reformulated in terms of the on-farm trials of the previous year and the impressions of all participants in the trials. They are also modified to incorporate findings from experiment station research. Once farmers and researchers are convinced that an appropriate strategy is available, i.e. one consistent with farmers' circumstances and promising significant improvement in income at acceptable risk, the strategy is verified on a larger number of representative sites. Once verified, firm recommendations are made.

Notice this process accents immediacy where improved technologies are available in the near future. If all goes well--if the proper elements have been integrated in the research--the recommended technologies will be widely and rapidly diffused. This occurs precisely because they have been deliberately tailored to fit the needs of the representative farmers in appropriate areas.

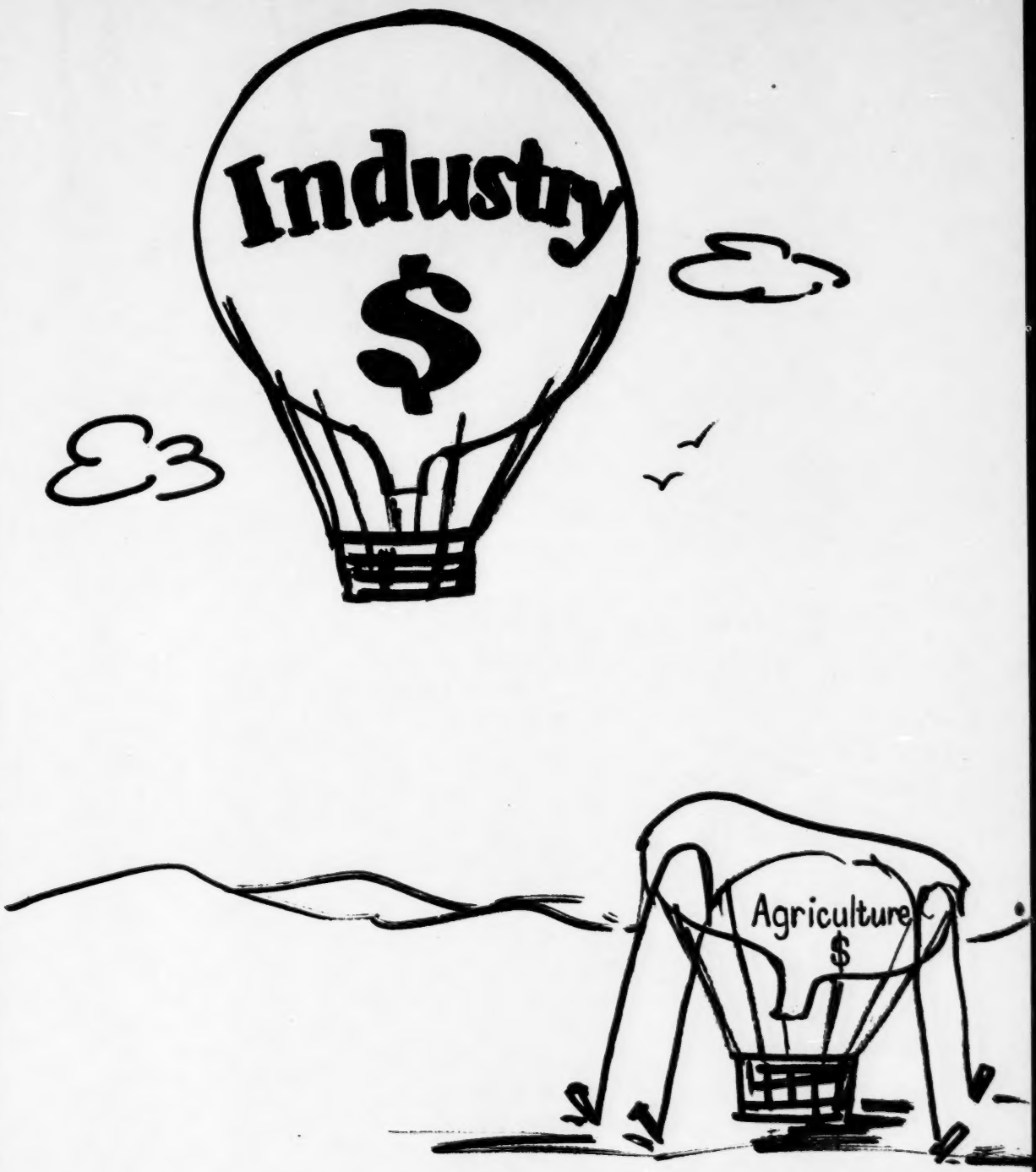
Over time, individual farmers will adjust the recommendations in the light of their particular circumstances. Experiment station results, e.g. new varieties, will be available for testing under farmers' circumstances and incorporated in new best-bet strategies. In the longer run, researchers will turn their attention to other environments or to other problems of lesser importance in the same environment. The process then, provides for continuing improvement in recommended technologies as both farmers and researchers--from on-farm trials and from experiment stations--apply new experience and information to farmer problems.

Incentives and Structure

The process described here rests squarely on bringing publicly sponsored researchers together around the problems of representative farmers. By basing research on representative natural and economic circumstances, researchers will play that important integrative role. In many cases, however, implementing such research will require changes in incentives and in work rules. For at least some researchers, professional incentives must favor contributions to representative farmers and to production; also, work rules must facilitate on-farm efforts.

Before making these changes, of course, the utility of the procedures themselves must be demonstrated. We believe that favorable evidence is accumulating rapidly. Already several national programs that CIMMYT has sponsored are recasting research in terms of the earlier discussion, and their on-farm activities are showing new solutions for the problems of representative farmers. These solutions are moving towards verification. We have yet to see whether they give rise to recommendations suitable for the target groups of farmers , but we are optimistic about developments.

[Extracted from a paper presented at the Seminar on Socio-Economic Aspects of Agricultural Research in Developing Countries; May 1979, Santiago, Chile.]



AGRICULTURAL PRICING POLICY

CARTOON ILLUSTRATING TENDENCY IN MANY COUNTRIES TO HOLD DOWN AGRICULTURAL PRICES WHILE ALLOWING INDUSTRIAL GOODS PRICES TO RISE, FAVORING OWNERS AND WORKERS IN THE INDUSTRIAL SECTOR. (GRAPHICS: BARBIERI AND GREEN, WASHINGTON, D.C.)

Agricultural Pricing Policies in Developing Countries

Gilbert T. Brown

[This article presents the case for allowing market prices to prevail for farm products and inputs in most cases. The negative results of holding down food prices to benefit urban consumers include lower food output, lower incomes and retarded development in the rural areas where most of the poorest people live, less savings and investment nationally, and balance of payments problems.]

Most developing countries for the last quarter century have had policies designed to lower the prices of food and other agricultural goods and to increase the prices of manufactured goods. Trade and foreign-exchange controls have been major instruments of these policies, along with taxes, direct price regulations and other market-control measures. The conventional wisdom supporting this twisting of the terms of trade against agriculture has had four main pillars, based on the assumptions:

(1) that aggregate agricultural production is not very responsive to price changes;

(2) that the chief beneficiaries of higher prices would be the larger-size farmers;

(3) that higher food and other agriculture-related prices such as clothing would most adversely affect low-income consumers; and

(4) that manufacturing provides a more rapid means of growth, and that achieving that

Mr. Brown is an economist with the World Bank, Washington, D.C.

growth depends upon large transfers of income (profits) and foreign exchange from agriculture to manufacturing. Thus, policies that depress agricultural prices and increase manufacturing prices have been expected to result in more rapid economic growth and in a more equal distribution of income as well.

Lagging agricultural production and a slowing of economic growth rates in many developing countries that followed such policies, however, have led to increasing concern about measures that reduce farm incomes and incentives. Argentina, Egypt, Kenya, the Ivory Coast, Pakistan, Peru, the Philippines, Thailand, and Uruguay are among the countries which have acted to significantly increase agricultural relative to nonagricultural prices in the 1970s. Greater emphasis in the development literature on rural-development strategies, and on strategies to meet basic needs and to benefit persons in the lowest 40 percent of the income distribution, has also provided new intellectual support for price policies more favorable to agriculture, such as lessened subsidies for capital goods, less overvalued exchange rates and protection for industry, and increased production of foodstuffs and other wage goods.

In contrast to those of the developing countries, price policies in the industrialized countries during this period have been distorted in favor of rather than against the farmer; the typical problem has been overproduction rather than underproduction of agricultural commodities. Moreover, greater agricultural productivity per hectare in industrialized than in developing countries is a phenomenon that has occurred largely since the 1930s, and within the period of differential price policies. In the period 1934-38, grain yields averaged 1.15 tons per hectare in industrial countries, and 1.14 tons (i.e., the same level) in developing countries. By 1975, however, grain yields in industrial countries were more than double those in developing countries, 3.0 tons versus 1.4 tons per hectare. This is not to argue, of course, that the more rapid growth in agricultural yields and production in the industrialized countries is due solely to differences in price policies. A plausible hypothesis is that both the more favorable farm prices and the more rapid growth of farm yields in industrial countries reflect efforts to support farm incomes and increase agricultural productivity, while developing countries have generally been much more concerned about increasing industrial incentives and production, and urban incomes.

The focus of this paper is not on the factors that explain the differences in growth rates between developed and developing countries, however, but on the effects of prevalent pricing policies in

today's developing countries. My hypothesis is that agricultural production, income distribution, and economic growth would all benefit from reduction or elimination of "distortions" that reduce agriculture's domestic terms of trade. By distortions, I mean government policies which change prices from what they would be in a free market with no controls. The relations of agriculture's domestic terms of trade to income distribution and economic growth particularly are complex problems too important to neglect.

Several general problems of terminology or analysis should be briefly mentioned. References to "free-market" prices are to those that would exist in the absence of specific controls and policies that now distort the relation of agricultural to nonagricultural prices, including those relationships that magnify differences between domestic and world-market prices. This is not to imply that world-market prices are "free," or that policy should aim to equate domestic and world-market prices or price relatives at all times. Neither is it to imply that "shadow" free-market prices (i.e. those which would be found under perfect market conditions) can be known with exactitude; we are inevitably dealing with a second-best or even third-best world. Rather, the comparison to probable prices "in the absence of controls" reflects only a judgment about approximate price relationships (e.g. too high, or too low). References to changes in prices are to changes from existing distorted price relations. It must be remembered, however, that prices are an incomplete measure of incentives. If agriculture's relative productivity is increasing, it is possible for agricultural incomes and incentives to be growing at the same time that agricultural prices are declining. A fundamental distinction must be made between measures such as price controls, taxes, and subsidies that artificially lower food and agricultural prices, and measures such as on-farm investment, technological advances, and rural infrastructure development (e.g., roads, electricity, and water), that lower prices by lowering the real costs of production. Reductions in real resource costs of production can benefit urban dwellers, farmers, and rural laborers alike.

Pricing Policies and Agricultural Production

Efficient use of resources. Higher prices may stimulate agricultural production by causing farmers to use more labor and other variable resource inputs to reach higher output levels with existing methods of production, or by inducing investment and the discovery and adoption of new agricultural technologies that result in new, lower-cost production possibilities.

The usual empirical basis of arguments that agricultural production is not very responsive to price changes rests upon low price

elasticities derived from multiple-correlation analysis of the acreage or output of a particular crop in relation to the relative prices of that crop versus others, or to several presumably independent variables such as output price and use of fertilizer, labor, and water. This multiple-correlation methodology can be faulted on several grounds, including the lack of independence between prices, on one hand, and the level of use of fertilizer and other inputs. The use of acreage rather than output in most such studies underestimates the price elasticity of production by not taking account of changes in yields, which for some years have been accounting for more than half the annual growth in world food-grain production. Also, it is doubtful that yearly fluctuations in prices can adequately represent the changes in the longer-run income expectations that determine rates of investment in agriculture and the adoption of new techniques. These decisions appear to depend more upon whether expected profitability is above or below a "threshold" level of acceptability, which may be little affected by yearly price fluctuations unless these cause longer-run expectations of profitability to change. Moreover, incentives are a function of net income and not just prices, so that a new technology may importantly change the incentive effect of a given set of prices--as happened during the Green Revolution in wheat and rice.

Price incentives can cause farmers to use improved seeds, along with more fertilizer, pesticides, and other purchased inputs, to adopt improved cultural practices, and to apply more family or hired labor. All of these ways of increasing the efficiency of resource use may occur at once, for example, if a small farmer decides to reduce or give up his off-farm employment--or a son does not migrate to the city--in order to adopt the more labor-intensive techniques required to reap the benefits of new varieties. Generalities about most small farmers as "subsistence" farmers unaffected by agricultural prices are highly misleading.

Timmer and Falcon (1975) found a close rank correlation between unmilled rice prices and rice yields among Asian countries. For 1970, rice yields varied from 5.64 and 4.55 metric tons per hectare in Japan and South Korea to 1.7-2.1 tons per hectare in Indonesia, Thailand, the Philippines, and Burma. At the same time, the ratio of the price of a kilogram of rice to the price of a kilogram of fertilizer nutrients showed a similar wide variation, from 1.43 and .96 in Japan and Korea to 0.1-0.4 in the other countries. This pattern of relationships between prices and yields cannot be explained as a short-term response, but reflects long-standing differences in price policies among these countries. It appears to indicate long-run responsiveness of production to incentives. It is noteworthy that the three countries with the highest yields--Japan, South Korea, and Taiwan--have some of the poorest soils among the nine countries

studied. The high prices to farmers in these countries appear necessary to cover the costs of achieving these yields under the given climatic, soil and other conditions; the decisions to pay such high prices may have been primarily political. It is interesting to speculate to what levels rice yields and production would fall in Japan if farmers there received the same price as Thai farmers, or conversely the levels to which rice yields and production would climb in Thailand within a few years if Thai farmers faced the same rice and fertilizer prices as Japanese farmers.

Shifts in the production function. The most important long-run effects of price incentives on production may be through price-induced shifts in the production function (i.e. development of new technologies) rather than through greater efficiency of resource use with existing production functions (technologies). These long-run effects depend upon the extent to which the incentive structure has an important effect on scientific research and on adoption of new techniques by farmers, on public and private investment related to agriculture, and on institutional changes such as land reform, extension services, marketing, and distribution facilities.

Clear links have been demonstrated between prices and the timing and nature of new technological discoveries, and also the adoption of these techniques by farmers. Much of the agricultural research initiated since the late-1973 jump in oil prices is "energy saving," with heavy emphasis on reducing fertilizer requirements--for example, through nitrogen fixation, seed treatment, and placing a small amount of fertilizer close to the seed or seedling roots. Studies of the diffusion of new techniques and of new investment in developing countries indicate that where profitability of adopting a new technique or investing, say in a tube well, is very high, that the new techniques will be rapidly adopted and the new investment quickly made. At least there are wealthy individuals who make choices between agricultural and nonfarm investments. A large proportion of upper- and even middle-class individuals in South Asia, for example, reside in cities but own substantial farmland operated by a hired manager, tenant or a relative. For these individuals, as for the small farmer deciding how to divide his time between his own farm and other employment, the choices between farm vs. nonfarm investment and labor are recurring ones. Higher returns to farming certainly attract more labor and more investment into farming--other things being equal. Nearly all studies show high marginal saving rates among even poor farmers. Thus, an important part of the additional income accruing to farmers through higher prices is likely to result in greater savings and investment. In countries where farm yields are low and returns to additional investment in agriculture are high (e.g., where fertilizer use is well below optimal levels), an important part of that saving is likely to be invested in farming.

Public investment and institutional changes may also be importantly affected by prices, but research on these topics is in its infancy so the evidence is scarce.

Income Distribution

Low prices for food and other farm products are politically popular on the theory that they increase real incomes and employment of the urban poor, and that the only losers are large farmers. There is a high cost attached to such low prices, however, if their effect is to retard cost-reducing investment and innovation in agriculture. Competition between farmers and traders assures that most of any decline in unit costs would be passed on to consumers in lower prices, even though farm incomes rise. Moreover, studies of the effects of price distortions and controls in specific countries usually conclude that it is the upper- and middle-income urban groups (including employers) and large farmers who are the chief beneficiaries.

The argument that higher food prices hurt low-income urban consumers who have to buy most of their foodstuffs is usually based on the short-term income effects of higher food prices on the assumption of unchanged incomes. These studies tend to ignore even relatively short-run adjustment processes that reduce the income loss, such as shifts in consumer demand toward substitute foodstuffs, and the fact that in low-income countries urban wages usually respond fairly quickly to the cost of basic foodstuffs. The logic of the common argument in developing countries that food prices must be kept low in order to assure the competitiveness of manufactured exports rests entirely on this relationship between the two. The benefit to employers of below-market agricultural prices is even clearer in the case of nonfoodstuffs: cotton yarn and textile manufacturers in Pakistan, for example, for many years have been able to buy cotton from farmers, many of whom are quite poor, at no more than two-thirds and sometimes half of world market prices because of foreign exchange and export tax controls; but they sell much of their output at world market prices.

Price and production controls that are intended to provide low-cost food to poor urban groups also tend to divert production away from those cheaper food crops. In Peru, low official prices have greatly reduced production of *frijol canario*, a popular bean which has been a major source of protein for low-income urban consumers; the limited output is being channeled through black markets at prices about 60 percent above the official control prices. In Egypt, farmers have increasingly diverted land, fertilizer, and other inputs from growing wheat, maize, rice, and cotton--for which they are given quotas to sell to the government at low, controlled prices--to growing fruits, vegetables, and livestock, which are not price-controlled. This diversion helps assure a supply of these latter

foods for upper-income urbanites, but at a high cost in the balance of payments and in massive budget subsidies to lower the retail price of imported wheat. In Kenya, price ceilings on meat and maize transfer income from low-income herdsmen and farmers for the benefit of middle- and upper-income urban dwellers.

Marketing controls. Most developing-country controls on price margins and marketing between farmers and consumers are supposed to protect consumers against "monopolistic" traders. The few significant studies of such controls, however, suggest that such interventions frequently have very adverse effects on efficiency, production, and income distribution. The most comprehensive Indian study concluded that the private grain market was highly competitive, that traders operated efficiently within government-imposed technological and policy constraints, and that government efforts, rather than being expended in market controls, could have been much more fruitfully directed toward helping to improve the competitive environment, including improved farm-to-market transportation facilities, dissemination of market price and stock information, and managing national support price and buffer stock programs. Periodic threats by the Indian government during the prior twenty-five years to nationalize all trade in grains, and the issuing of new rice-milling licenses primarily to cooperatives and public-sector firms, however, had resulted in very little private investment to improve either storage or milling facilities. Furthermore, government-agency marketing costs are several times as high as those of private traders, who flourish despite government policies.

A study in Peru concluded that marketing measures initiated to eliminate abuses by middlemen represented one of the major constraints limiting agricultural production, and might drive out private marketing talent with no comparable gain in public-sector expertise. Because of stringent laws and penalties against speculation and monopolization, there is little private investment in storage facilities in Peru. This lack of storage facilities results in periodic gluts, scarcities, and excessive price fluctuations as wholesale truckers move products between consumption centers on a day-to-day basis to take advantage of price differences among different areas.

Input subsidies and income distribution. Farm subsidies also benefit primarily middle- and upper-income farmers in low-income countries. Large-scale farmers buy most subsidized inputs. Poorer farmers usually lack the money to buy adequate amounts of fertilizer and pesticides, and are commonly unable to get credit except at near-prohibitive private rates of often 60 to 100 percent per year. In countries with subsidized bank credit for agriculture, rich farmers tend to get most of the credit through open or disguised bribery. Subsidy programs for tractors, tube wells, and other fixed investments also go mostly to the largest and richest farmers. Data from

Kenya indicate that about 80 percent of fertilizer, which has been subsidized for many years, has gone to large farmers.

Development Strategy and Agricultural Pricing

The ultimate question about agricultural pricing policies is their effect on economic development, including income distribution and social consequences. We are unable to model and quantify adequately an entire economy in a way that measures its complete response to variations in relative prices. We can progress toward that goal, however, by examining the effects of agricultural-pricing policies on government budgets, national saving and investment, and the balance of payments.

Government budgets. Revenue and expenditure data shed further light on the effect of government actions on farmer incentives and income distribution. We have made calculations of the transfers of resources among producers, consumers, and the government due to the effect of government measures on the prices received by farmers and the prices paid by consumers for wheat in Pakistan in various years between 1966 and 1976. These show a large transfer of income from wheat producers to consumers through lower-than-world-market prices for domestic wheat, including that procured by the government. These transfers are estimated at 348 million rupees in 1966 and 1,540 million rupees in 1976, and they equalled 62 percent of the income received by farmers from marketed wheat in the former year and 52 percent in the latter. At the same time the farmers received budgeted government subsidies on inputs used in producing wheat equal to about 7 percent of the domestic value of marketed wheat at domestic prices in 1966 and 10 percent in 1976. Consumers received transfers from less-than-world prices for their purchases in the private market, and from sales through officially controlled ration shops, of both domestic and imported wheat at substantially less than their cost to the government. The net result of these transactions has been a large income transfer from producers (1,237 million rupees in 1976) equal to 41 percent of the value of marketed wheat at domestic prices, and a large income transfer to consumers (3,280 million rupees in 1976) equal to somewhat more than the total payment to domestic farmers for their entire crop of marketed wheat.

One of the important questions is whether the benefits of these subsidies in providing lower-cost wheat to consumers are as great as their costs. The economic and social costs are increases in taxes and/or government borrowing, or of decreases in other government expenditures--perhaps a combination of these. All consumers are beneficiaries of the system, whether they buy government-rationed and price-controlled wheat or make their purchases in private markets. The cost of these subsidies weighs heavily on small "subsistence-level" farmers. In Pakistan, such farmers sell more

than 30 percent of all marketed wheat but receive only a small fraction of the fertilizer, pesticide, tube well, tractor, and other subsidies. The average real income of these small farmers is considerably below the average urban income.

As for cost effectiveness in reaching really poor consumers, many of those in the lowest 40 percent of the income distribution are farmers or rural workers who would benefit from higher farm prices; and some of the poorest urban dwellers would have stayed on or returned to farms if farm prices and incomes had been higher. These facts suggest that low food prices penalize rather than help many of the poor. The 2 billion rupees of government budget subsidies to lower wheat prices in 1976 amounted to one-half the value of all marketed wheat, including imported wheat. Thus, on budgetary grounds alone, ignoring production and other indirect effects, this is an extremely expensive way to provide low-priced wheat to those who are in real poverty; it could be done at much less expense through a direct food subsidy or other income-supplement program directed to the needy and malnourished.

A typical and in no way exceptional example of the relation of the cost of these budget subsidies to expenditures on agricultural extension, research, education, and statistics is available from Pakistan budget data. For fiscal year 1975, subsidies to consumers for wheat and to farmers for purchased inputs at the provincial and national government levels were budgeted to equal about 60 percent of all other current and capital expenditures on agriculture, irrigation, and water development projects. The cost of subsidies was drastically underestimated, however, and actual payments amounted to about 90 percent of the budgeted level of the type of expenditures noted. Actual wheat subsidies were forty-four times as great as budgeted expenditures on extension services, and fifteen times the total budgeted expenditures on agricultural extension, research, education, and statistics. It seems unlikely that the benefits of wheat subsidies were as great as would have been a near doubling of the real resources devoted to all agriculture and water development programs. It also seems likely that increased expenditures on these latter categories would have done far more than the subsidies to lower food prices, though with a time lag.

Taxation. There is a substantial literature on the economic advantages of direct rather than indirect taxation of agriculture, since land and income taxes do not directly affect either relative product prices, cropping patterns, input/output price ratios, or the output levels from which farmers will realize the maximum levels of income. High levels of land taxation were very successfully used, both to stimulate agricultural output and to transfer resources to the government and to industry, during the modernization of agriculture in Japan and in colonial India. However, the lack of signifi-

cant levels of such taxation in most developing countries today, and the presumed administrative as well as political difficulties in their imposition, are often cited as reasons for focusing on indirect taxation of agricultural commodities, and particularly on taxation of exports. Changes in taxation would be a budgetary requirement of price and subsidy changes in many countries. A package combining higher output prices with reduced subsidies and increased land taxation could work to everyone's interest, and be more politically acceptable than a change only in prices and subsidies.

Savings and investment. The effects of pricing policies on national saving are obviously very complex. Budget subsidies to consumers during the high grain prices of the 1970s rose to roughly one-fourth of total government expenditures in some food-deficit countries such as Egypt and Pakistan, and to as much as 5 percent of gross domestic products. These were exceptional years; but such subsidies are typically still a significant drain on saving and hence on resources available to finance investment.

Substantial savings may also be lost through income transfers from agriculture to the rest of the economy through price distortions. Studies of private saving rates among rural and urban groups show higher marginal saving rates in rural than in urban areas. Furthermore, small-farmer marginal saving rates appear to be almost as high as those of large farmers. Farm saving rates might have been further increased if pricing policies had made investment in agriculture more attractive. Thus, the distortion of input and product prices in order to funnel income away from farmers and toward industry may have significantly reduced national rates of saving and, therefore, of investment. Rates of overall economic growth may hence have suffered from lower rates of saving and investment as well as from misallocation of budget and investment funds. This is just the opposite effect, of course, from that predicted by economists who argued in the 1950s and 1960s, from inadequate empirical data, that marginal saving rates of the urban sector and industrialists were higher than those of farmers.

Observation of the industrial sector in many developing countries suggests that relatively little productive investment may result from the involuntary transfer of income from agriculture to industry. Rates of utilization of physical capital in industry are extremely low in these countries. Moreover, much of the income transferred may not even result in productive investment but may be frittered away in inefficiency and increased consumption, such as in wage increases to already relatively high-income industrial workers, additional unneeded employment of workers (especially in public-sector industry), or increased consumption by managers.

Balance of payments. While the totality of potential effects of relative changes in agricultural prices upon the balance of payments is very complex, spectacular balance of payments changes appear feasible in some countries by reducing price distortions against agriculture. Kenya's move in early 1975 toward world-market prices for both agricultural products and inputs has virtually eliminated previous large expenditures for wheat and sugar imports, both by increasing domestic production of these crops and by cutting demand for each by about 20 percent through substitution of other domestic foodstuffs. Reduction of subsidies on imported farm equipment that have mostly benefited rich farmers and encouraged capital-intensive and import-intensive agricultural production techniques seems to be simultaneously strengthening the balance of payments, increasing wheat production and lowering its cost, and improving incomes and employment among relatively poorer sections of Kenya's rural population. By contrast, declines in rice exports from Burma, and in agricultural exports from Pakistan and Egypt, are only a few examples of the sometimes very substantial declines in export earnings that have resulted from paying farmers much less than the market value of their crops.

Higher agricultural prices closer to market level might also significantly reduce nonfood imports by changing the distribution of income and hence the composition of demand. If less discrimination against agricultural prices shifted income distribution in favor of farmers, there would be changes in the composition as well as the level of demand for both consumption and investment goods. Research indicates that such shifts would tend to increase demand for labor-intensive domestic products and reduce demand for capital-intensive and imported products.

Conclusions

Analysis of the significance of price policy in general and agricultural price policy in particular has not kept up with practical experience concerning policies affecting prices in developing countries or with changes in development-strategy theories. There are several types of studies that might be especially useful in advancing our knowledge of the responses of farmers and of national economies to price changes. First, detailed case studies of the decisionmaking of individual farmers are badly needed. Much of our "conventional wisdom" about farm-level response to changes in agricultural prices, for instance, is based upon aggregative data. Studies have only recently begun on how developing-country farmers of different income levels spend their time and earn their incomes.

Second, detailed case studies of the effect of particular price policies in individual countries are needed. Evidence from various

sources has been presented in this paper about some consequences of particular price policies in particular countries. Such material needs to be much more systematically examined and incorporated into the knowledge of development specialists and policy makers; information is available and is too often regarded as interesting anecdotal case material. The problem is too important to neglect. In the process of seeing what can be accomplished with current tools of analysis, new analytical breakthroughs appear likely.

Third, it is important that the overall structure of price policies be studied, along with the place of price policy in overall economic policy. Such studies have generally not been undertaken because they are considered "unwieldy," "vague," and too big to be productive. Nevertheless, the examples cited here of the neglect of agricultural pricing issues suggest that these issues are also too important not to be the subject of some direct work, rather than always working with the pieces. These studies will necessarily be national studies initially. It would also be useful to look at comparative policy structure and growth experiences in different developing countries since perhaps 1950. For example, what were the characteristics of price policy and overall economic policy in countries with rapid overall growth, and how did these policies compare with those of countries which experienced difficulties?

Fourth, the role which developed countries could play in helping to overcome agricultural pricing policy problems in developing countries should be examined. For instance, could foreign aid help to finance a phased adjustment in urban food prices over several years, both to avoid sharp short-term income effects from higher prices and to cover the period between the undertaking of farm-level price increases and the actual achievement of increased and cheaper food-grain supplies? Developed countries could also make an important contribution by managing their own agricultural production and import and export programs so as to minimize disruptions to world markets.

[Extracted from Distortions of Agricultural Incentives, Theodore W. Schultz, editor, pp. 83-101. Copyright© 1978 by Indiana University Press, Bloomington, Indiana.]

Agricultural Price Management in Egypt

William Cuddihy

[A World Bank study of the effects of Egyptian agricultural price controls and related interventions since 1952 concludes that most of the results were adverse: slow growth or decline in yields and output, too little investment except for luxury food products, with the greatest negative impact on the poor farmers and the poorest sector of the population.]

For many years after the 1952 Revolution Egyptian agriculture had been associated with excellent yields and a well managed program of agrarian reform. Over the last ten years, though, growth rates in yields of many important crops like sugarcane and cotton have fallen, and rising food import costs have become an important competitor for foreign exchange needed for industrial development. By 1976 the foreign exchange cost of agricultural imports was 70 percent more than the foreign exchange earnings from agricultural exports. The government's Five Year Plan, 1978-82, voices the official opinion that agriculture has become a problem because its performance is consistently below expectations and has become increasingly difficult to administer. Public administrators complain of "peasant perversity" in not accepting new technology, in not cooperating with the State's production plans for the common good, and in not responding correctly to the price increases conceded them. Farmers complain of government interference in markets that leads to low crop prices, fertilizer shortages, and forced membership in unpopular cooperatives. This paper is the result of a detailed examination of Egypt's use of market intervention as a major tool of economic management.

The author is an agricultural economist with the World Bank, Washington, D.C.

Sector Background

Although Egypt has adopted a conscious policy of industrialization since 1952, the country remains essentially an agrarian one, and the industrial drive has resulted in a manufacturing sector which has failed to absorb sufficient labor migrating from the rural areas. The industrial development has been financed basically by taxing the agricultural surplus.

Egypt's farmland is a long narrow oasis in a large desert. Only three percent of the total land area is cultivated, and there is little scope for extending it since it depends on water from the Nile River. The population density relative to the arable area is very high (12.5 per hectare), and the average size of holdings is very small at 1.47 ha. The cultivated area, however, has fertile soils--mostly riparian silts and clays of great depths and uniformity--and the land is well suited and the long hours of sunlight permit excellent growth rates. The development of the irrigation network has resulted in cropping intensity of 190 percent in a complex rotational system.

Maize and sorghum are the main subsistence crops, while wheat, beans, and onions are the leading winter cash crops; cotton and rice are the main summer cash crops. Berseem has become an important cash crop for feed for draft animals, upon which Egyptian agriculture depends, and for beef feedlot operations. Crop yields have either declined (cotton, rice, sugar and beans) or risen very slowly (wheat and maize). One result of this is that Egypt has changed from being a net exporter into a net importer of wheat; and cotton and rice exports have declined.

Public investment in agriculture has been considerable since the Revolution, with most of the funds going to finance the Aswan High Dam and to opening up fringe desert areas for irrigation. The results of reclaiming new marginal lands have been disappointing so far, and there has been too little investment in projects intended to raise productivity on the old lands. The major evidence for this conclusion is the lagging growth rates in yields for major crops and even declines in the yields. Farmers are organized in government-operated cooperatives; they receive most of their inputs through the cooperatives, and have to sell varying proportions of their outputs to them. Evasion of planting requirements and sales quotas is believed to be widespread, with many farmers prepared to pay the fines if caught.

Goals and Policies

Egyptian agricultural development strategy derives from two sets of policies, which this study shows have tended to conflict with each

other. On the one hand, the strategy embodies an industry-led policy of economic development which was widely recommended in the 1950s. That policy was based on the theory that, since productivity is generally higher in manufacturing than in agriculture, priority should be given to industrialization; other sectors will then benefit from the trickle-down effects. The policy instruments for achieving the strategy have been (a) taxation of the agricultural surplus to provide the industrial investment funds; (b) protection for infant manufacturing industries; and (c) maintenance of relatively low industrial costs through cheap food and low wages. The policy instruments certainly worked: the agricultural surplus was tapped, industries were protected, and the price of basic foods, particularly bread, was kept low despite inflation.

The second set of policies are distributional in intention, and were rooted in the revolutionary reaction to the onerous conditions in the countryside prior to the revolution. Along with the land reform--the basic means of redistribution--a number of physical controls (state ownership and state production, private controls and subsidies) were introduced. From time to time, in response to pressures and changing situations, additions and changes were made which have now resulted in a patchwork of uncoordinated market interventions.

Effects of Policy Instruments

Effect on prices. If one compares import or export prices, adjusted to the farmgate by deducting the costs for transport, trade and processing (that is, "border prices"), with the prices actually paid to farmers, one finds long run "taxation" of export crops, little difference for basic foodgrains, and "subsidization" of meat and sugar production. (Taxation, as used here, means that border prices are higher than actual farm prices; subsidization is the opposite.) Between 1965 and 1972 the tax rate measured in this way--"nominal protection"--was around 30 percent for the export crops of cotton, rice and onions. Wheat and maize prices were close to border prices, whereas those for meat were well over twice the import equivalent. During this period world prices of sugar were very low. Processing costs occasionally exceeded the price of the final product for some crops. A sharp change occurred between 1973 and 1976 when the world prices rose dramatically while Egypt's administrators kept local prices constant, resulting in taxation of all products except meat. The tax rate on cotton, rice and onions peaked at 60 percent, 80 percent and 60 percent respectively, then began to fall as domestic producer prices were increased and border prices started to decline. Wheat and maize price taxation reached 30 percent, and the sugar subsidy became a 70 percent tax. Local price rises for meat matched foreign gains, and the subsidy rate remained constant. The spectacu-

lar widening of price distortions at that time led to markedly increased attention being paid to market problems.

The tax rates on output prices as measured by nominal protection do not tell the full story since certain inputs and services are also provided at distorted prices. For instance, domestic fertilizer prices have been kept constant since 1961 while import prices have fallen and risen. Between 1965 and 1973 this practice resulted in farmers paying up to 87 percent more for their fertilizer, obtainable only from the state monopoly. Between 1973 and 1976, as world prices escalated, the same policy resulted in their paying only half the world price. For all the other purchased farm inputs there has been a subsidy in all years, mostly the result of rising world prices diverging from constant domestic prices. By 1976, fuel, pesticides, interest rates, tractor purchase, trading charges, rents, and land taxes were all subsidized by some 50 percent. Irrigation water was still free, and improved seeds received subsidies--up to 30 percent for hybrid maize. The long run practice has been a net subsidy on inputs gradually rising to a weighted average of around 50 percent.

The combined effect of these distortions is a long-run net tax on the agricultural sector estimated at 30 percent of value added. Since the estimates of "effective protection" rates, which include input subsidies, do not markedly differ from those for "nominal protection" which looks at output prices only, the value of input subsidies does very little to compensate for the value of product taxes. The budget cost of all direct and indirect producer subsidies between 1973 and 1976 is shown as £E 602 million. This includes all explicit subsidies on all crops, the current expenditure of both the Ministries of Agriculture and of Irrigation to provide water and services, plus all state investment in the sector. The direct state revenue, net of payments to growers, from cotton sales alone was £E 892 million arising from use of the discriminatory overvalued exchange rate and from price differentials in terms of local currency. In other words, state revenues from cotton alone more than paid for all state expenditure in agriculture. To the cotton revenue must be added the value of the 50 percent tax rate on rice and onion exports, as well as the differentials on the value of orange exports. Similarly, the substantial implicit transfers to consumers by setting relatively low producer prices for wheat, maize and sugar in this period should be included as state revenue.

Measurement of the effects of market intervention on farm prices is important for national development only where prices matter. The planners' implicit assumption that prices do not matter, which was central to Egypt's policy planning, is based on the following reasons: (1) offsetting measures like consumer subsidies can be used to correct income imbalances; (2) non-price controls can be applied to restrict resource reallocation in response to price signals;

(3) direct state investment can divert resources to projects regardless of market signals about profit expectations.

Effect on cropping patterns. Our analysis of farmers' response to price changes over the 25 years since 1952 by use of regression equations shows significant correlation of relative prices with yields and cropping patterns. Both planted area, a measure of land allocation, and yields, a measure of the use of other inputs, have varied positively with changes in the relative prices of outputs over the long run. However, the short-run responses were much limited by rotational requirements, by poor access to markets for high priced perishable products, and the paucity of the farmers' resources as well as by policy controls on the supply of inputs and the pattern of production. These results are confirmed by field observations, and acknowledged by the government. Some examples of the ways in which farmers react to price situations and get around government controls are as follows: Secondary markets are very active in the reselling of fertilizer alloted to each farmer in fixed amounts on the basis of the expected area of each of his crops. Every year many thousands of farmers pay a fine rather than conform to the production plan set for them; for cotton, the number reached 180,000 in 1974. Sugar producers at that time diverted some 40 percent of their production away from the lower priced official markets.

The evidence clearly shows that prices have indeed mattered, in influencing what was produced, how it was grown and what was marketed, and that the planners' assumptions to the contrary have been invalid for a long time. But in the short run the degree of response has been severely limited by non-price constraints. The complexity of the relationships is borne out by empirical results which show, for example, a high long run elasticity of area planted with respect to income from rice (0.91) and wheat (0.46), and a high cross elasticity (9.95) between wheat and cotton. On the other hand, while both maize and cotton showed negative area response to their own prices, they both showed high yield response to output price changes.

The major conclusion of a study using linear programming of price effects on the structure of production [description omitted here] is that both prices and policy controls have had a major impact on the composition of the marketed surplus as well as on the total cropping pattern. It is clear that the desired production plan at the national level could be achieved with a less complex system of offsetting market controls and distorted prices which would be easier to manage; the optimum simulation, with farmers facing border prices for all outputs and inputs, would increase farm incomes by 40 percent.

Effect on input use. Price effects on the efficiency of input use have been important only in the case of irrigation water, where

studies show that free water has led to considerable wastage. Of the other inputs, price ratios have had little effect in determining the choice of technique since the quantities used have generally been restricted to a level well below the point where the value of the marginal product equals the cost. Secondary fertilizer trading has helped rationalize its use; application of cotton pesticide by government agencies is independent of farmer decisions; and the supply of machinery has been restricted. The best example of the ineffectiveness of price measures to influence technology innovations is the case of high-yielding grain varieties (HYV). Despite a seed price subsidy rising to 30 percent and an extension campaign to encourage its use, less than 1 percent of the rice area is under HYV varieties, compared to 64 percent for the Philippines and 30 percent for India. In the case of wheat, only 15 percent of total plantings were with HYVs, compared to 62 percent for India and Pakistan and 50 percent for the Sudan. The area under HYV wheat rose from 5 percent in 1973 to 37 percent in 1974 and dropped back to 13 percent in 1975. Reasons for rejection were: (1) the grain quality was not acceptable to consumers; (2) the ratio of straw to grain was too low to meet animal fodder requirements; (3) local adaption by researchers was insufficient to make HYVs as disease resistant as local varieties; (4) the cultural demands of the HYVs do not fit into the common farm systems.

Effect on aggregate output. Over the long run, the rate of change in technology and the growth in aggregate output in agriculture are functions of investment. Secular movements in commodity and factor prices determine the pattern and level of private sector investment allocation, both within agriculture and between it and other sectors. State investment has worked through direct resource allocation within the central plan; government-set prices determine the rate and origin of public savings mobilization from the sector, and hence the degree to which public investment substitutes for private investment. Most of the relatively minor amount of private investment has been directed to orchards, with little or no price distortion on output but considerable product-price protection. State funds have gone into infrastructure such as irrigation, drainage, land reclamation, research and extension with mixed success. Technology-changing investment in the traditional crops comprising most of the value of output has been relatively minor. The net result is that the long-run growth rate in agricultural production at constant prices has been low. The figure for Egypt is 1.3 percent per year, while for the developing countries as a whole it has been 2.6 percent and for the developed countries 1.8 percent. Egyptian crop yields no longer lead the world in major crops as in the sixties. Under a different set of long-run prices it would be fair to expect a more positive pattern and level of investment, and a different rate of growth in aggregate production.

Effects on incomes. The income effects of price management have proven to be regressive--i.e. unfavorable to the lower incomes. The analysis indicates a long-run average tax rate for the sector in the order of 30 percent, which is 20 percent higher than the average 25 percent tax rate as a percentage of GNP for the economy as a whole. Average incomes in agriculture are less than those for the rest of the economy by 25 percent. Despite the inexactness of some of the numbers involved, the orders of magnitude do indicate that the policy objective of equity between rural and urban areas has not been achieved by price management: incomes in agriculture have been depressed by policy instruments. On the other hand, since agriculture is the largest sector, this is where the largest part of the tax base lies. The problem is in devising a tax system to achieve both the revenue and equity goals simultaneously. Fortunately, the growth in earnings from the Suez Canal and from the remittances of Egyptians working overseas relieves agriculture of some of its heavy burden.

Perhaps more important is the taxation inequity within the sector. The tax incidence varies by crop, and cotton-based farmers bear a greater tax burden than specialist meat producers or fruit growers. To move into the latter crops requires investment, and orchards return no income for several years; feedlot contracts are given only if minimum-scale-of-operation conditions can be met. Long-term farm credit has not been available since the early 1960s, so only those with access to savings from outside the sector can exploit profitable opportunities made possible by the distorted price system. This effectively locks small farmers into a high-taxed cropping pattern. This conclusion is supported by field observation, where orchards were commonly found to be owned by urban-based professionals and where cattle fattening feedlots were commonly found to be operated by the dominant farmer in the village. This situation has occurred because of the inflexibility of price management to changing circumstances. The price control structure has been developed around the "traditional" crops of most importance at the time, and no restructuring has occurred despite the rise in importance of higher-profit "non-traditional" activities. The conclusion for welfare is that prices have mattered in determining relative incomes, and that price management has been regressive both within agriculture and between agriculture and the rest of the economy.

Effect on institutions. The basic questions still remain: Should the state have intervened to such an extent? Should more use have been made of alternatives to price interventions and physical controls? What have been the real resource costs? Following the revolution, and with the implementation of the land reform, administrators were left with the task of reorganizing the agricultural sector. Most of the farmers worked small parcels, had little previous access to credit, and their objectives were based on survival. The prior conditions of serfdom had hardly prepared farmers for a free market

system. It is arguable that during a transitional phase to "maturity" the State had little option but to fill at least some of the decision-making vacuum, and to ration goods and services as widely as possible. Even though specific efficiency losses can be ascribed to poor State control, such as the low cotton yields of 1977 due to a breakdown of the pest control operations--yet left alone, the multitude of small farmers, faced with escalating pesticide prices, might not have fared much better. However, there has been no way for farmers and institutions to learn from experience. Here is probably the intervention program's greatest social cost. The agricultural development strategy has put the system into a state of permanent dependence, with low accountability, poor motivation, and with little interest in innovation other than to use the rules to gain individual advantage regardless of their intent. Less stress on price stability, and more frequent changes in the face of rapidly increasing inflation might have resulted in a climate more responsive to change and more conducive to development.

Evaluation of the Net Effects of Market Interventions

A full evaluation of the effects of administered farm taxes and subsidies must assess the effects of policy instruments on productivity and income distribution, not only within the sector being examined but in other sectors as well. This requires more comprehensive, sophisticated, dynamic programming modeling than is possible. Our analysis of market interventions in Egypt had to be based on partial equilibrium analyses; but there can be little doubt that the patchwork of market interventions which have grown up in the years since the revolution have had very significant impacts on:

--productivity (lack of adequate investment in agriculture, particularly in raising productivity of the old lands);

--the output and export of crops (negative on wheat, cotton and rice; positive on livestock; berseem, fruits and vegetables);

--the use of inputs (e.g. waterlogging resulting from wasteful use of irrigation water);

--institutions, which have been unable to respond effectively to the balancing of supply and demand in product and factor markets (balancing which would otherwise be carried out by market forces);

--income distribution within agriculture and between agriculture and other sectors.

The input subsidies have nowhere offset the taxes on producers as the table below illustrates in part. Moreover, although the agricultural surplus has been effectively taxed, most of the taxed surplus has not been used to finance industrial investment as was in-

tended, but was transferred to consumers by way of subsidies. Too little was left for reinvestment in agriculture, and the share that did go to finance industrialization was not successful in creating enough new jobs in efficient manufacturing enterprises to employ those pushed out of agriculture.

Table 1: CONSUMER AND PRODUCER TRANSFERS IN MAJOR CROPS--EGYPT 1974/75
(in £E million at parallel exchange rates)

Crop	Transfer from Producers a/	Transfers to Consumers	Transfer to State
Rice	-562	+518	+ 44
Wheat	- 78	+334	-256
Cotton	-254	+122	+132
Sugar	-400	+ 40	+360
Maize	-120	+249	-129
Meat	+214	-242	+ 28
Total	-1,200	+1,021	+179

a/ Net of input subsidies

Policy Conclusions

What then are the options open to Egypt? It is suggested there are three choices:

--to have more of the same, but to extend the coverage of physical controls to all agricultural products; and to make the policy instruments internally more consistent;

--to dismantle all controls, remove all taxes and subsidies and rely entirely on market prices; and

--to move gradually towards a position of fewer physical controls, less direct and more efficient state production, less discrimination against agriculture as a whole, and a more rational system of taxes and subsidies which would encourage Egyptian farmers to adopt cropping patterns that would be more consistent with their own private needs and with Egypt's long term comparative cost advantages.

The first two alternatives are extreme ones. In view of the failure of the existing strategy, more of the same is unlikely to be successful; but moving quickly to a freer trade position is politically unacceptable and likely to be disruptive in effect. Hence the third alternative is recommended.

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Public Rice Distribution and Welfare in Sri Lanka

James D. Gavan and Indrani Sri Chandrasekara

[While some countries hold food prices down to help consumers, and others keep them high to help farmers, Sri Lanka--although a quite low-income country--has done both: supported farm prices of rice, and supplied rice rations at subsidized prices to almost all consumers. There have been some important benefits, but the cost was very great, and in 1978 the program was curtailed. This article analyzes costs and benefits of the unusual policy.]

Sri Lanka has achieved remarkable social progress for a country with a very modest economic base. Although its per capita income is very little higher than those in India and Pakistan, Sri Lanka has clearly achieved higher literacy and life expectancy, and lower infant mortality, than the other countries in South and Southeast Asia.

This progress appears to be at least in part the result of a series of social policies that have been followed in the country since and in some cases prior to independence. Among these are the food distribution programs. A comprehensive public rice distribution system has operated since World War II. Until 1978, almost the whole population of Sri Lanka received an allotment of rice; most of the time it was paid for by consumers, but at prices below cost. The system involves the distribution of rice at subsidized prices through an extensive network of some 7,400 cooperatives; and an active government program of price supports and procurement of agricultural commodities, particularly rice, to supply the public distribution system. This study explores the operation of the public food distribution system, how it affects

The authors are with the International Food Policy Research Institute, Washington, D.C.

the price and availability of foods, its impact on the food intake levels and nutrition of different income groups, and its costs.

A comparison of food intake in Sri Lanka with nutritional levels in other poor countries of Asia indicates that average consumption in Sri Lanka is not high and that protein intake is unsatisfactory. But the distribution of the available food among different income groups is remarkably even compared to that in other poor countries. This evenness is a result of relatively modest intake at the higher end of the income scale as well as relatively satisfactory food intake levels at the lower end of the income scale.

Sri Lanka is a food-deficit economy that traditionally has relied on imports of rice and wheat, which are paid for largely by the export of plantation crops. The most important Sri Lankan food staples are rice and coconut. No wheat is grown in the country. The government has pursued a policy of maintaining rice prices to farmers through the Guaranteed Price Scheme, encouraging production; also through irrigation, land settlement, and the subsidization of inputs. Rice production grew very rapidly, tripling from the early 1950s to the early 1970s (from 350,000 tons in 1950-54 to about one million tons). The cereal self-sufficiency ratio almost doubled in 20 years (from .36 to about .60). In the 1970s, however, production stagnated, partly due to droughts and partly to unfavorable rice/fertilizer price ratios.

The Sri Lankan government, through the Food Commissioner's Department, has a monopoly on the international trading of food commodities. The Food Commissioner's Department imports rice and wheat for the public food distribution system. Rice is distributed at subsidized prices through the ration system. Generally, wheat is available in unrestricted quantities at prices that are sometimes taxed and sometimes subsidized. Rice and sugar are distributed largely through a network of authorized distributorships at a fixed markup, whereas wheat is normally available through all retail outlets in the country. Rice is procured from farmers at a guaranteed purchase price by the Paddy Marketing Board, which, during certain periods, has limited all movement of rice within the country. The Board purchases all the rice offered by the farmer.

Operation of the System

Prior to 1966 the distribution system expanded rapidly helped by cheap rice imports; domestic production and procurement were also expanding rapidly. Per capita wheat imports and consumption declined. Then in 1966 through 1970 the size of the ration quota was cut in half, and the entire quota was made available free of charge. Prices rose in the open market; government procurement declined; and wheat consumption grew considerably. This was also a period of high domestic rice production and overall food consumption increased rather than decreased as a result.

In 1970 an additional paid ration quota was reintroduced at a significantly higher price. For the first time the paid portion of the rice ration cost more than wheat flour. A series of poor rice harvests combined with sharply increased world prices forced cuts in the system and drastic price increases beginning in late 1973; and for over a year wheat was also distributed through the ration system. Food intake levels declined between 1972 and 1975/76, and there is some evidence of a decline in nutrition standards.

The costs of operating the food subsidy scheme grew almost continuously with increases in population and domestic procurement. For a number of years, almost half the cost of the system to the government was covered by its profits from the sale of sugar and wheat flour at above official import prices. Low world prices for sugar and cereals during much of the 1950s and 1960s allowed the comprehensive system to operate at a sustainable net cost of approximately Rs 300 million per year in the late 1960s. But the offsetting revenue declined sharply after 1972 as a result of higher sugar and wheat prices, and the situation was further compounded in 1974 by the high world rice prices. The burden on the budget rose rapidly to intolerable levels: between 1970 and 1975 the net cost of the subsidy more than tripled. In 1978 the newly elected government sharply curtailed the system by removing the eligibility for rice distribution of approximately half of the population by the use of a means test.

Nutritional Effects

Consumer survey data used to examine utilization of the ration by different economic groups in rural, urban and estate areas and to estimate the net contribution of the ration to calorie consumption indicated that use of the ration was virtually universal, and that all segments of the community received some benefit from it. A high proportion of total cereals consumed was obtained through the public distribution system by all income groups. When converted into its cash equivalent, the value of the rice ration subsidy was equivalent to 16 percent of total income for the (lowest-income) tenth percentile of the population. This increment in income enabled them to increase consumption of a range of food products in the categories of animal products and oils and fats and to spend more for housing and clothing.

The 1969-70 socioeconomic survey data suggested that, on the average, one rupee of additional income resulted in an increased intake of 155 rice calories, 179 cereal calories, and 323 total calories. At the prevailing ration quantity and price, this translated into an increased calorie intake of only 63 calories per capita per day as a result of the ration for the average recipient (i.e., if there had been no rationing he would have eaten 63 calories less of total food). The impact was larger at the lower end of the income distribution, where the marginal propensity to spend on calories is

higher. For individuals in the bottom tenth percentile of the income distribution, the effect of the ration in 1969-70 was to raise calorie intake by 115 calories per day and protein intake by three grams. The very poorest of the poor might have benefited significantly more nutritionally than the results reported above indicate. Nevertheless, this had a relatively high cost per calorie of Rs 4.10 per thousand for the added nourishment delivered.

Thus in 1969-70 only a fraction of the rice calories put through the ration system had an impact on reducing the calorie gap. The rest went to substitute for market purchases, or to raise the consumption levels of people already receiving their required levels of intake. About as much non-rationed rice was consumed as rationed rice, and the former was thought to have better quality. The poor added about two-thirds of the rationed amount to their 8 pound per month ration--on average; the rich added perhaps twice as much of the non-rationed rice.

In the 1970s cereal consumption became less stable and more closely tied to domestic production. Bad harvests in 1972, 1973, and 1975 were instrumental in leading to low consumption levels that appear to have caused some decrease in nutrition and health standards in the country. FAO estimates were 2,306 daily calories per capita in 1966-71, falling to 2,071 in 1972-77. Thus, cutbacks in the ration subsidy system beginning in 1967 seem to have left consumers more vulnerable to instability.

The benefits of the ration program were attained at a high cost to fiscal resources. It is arguable that the cost was sustainable during the 1950s and the first part of the 1960s, when it was possible to take advantage of favorable conditions in world markets, including the low prices for flour and sugar that helped offset some of the burden. But under the more difficult conditions prevailing in the 1970s, the increased costs of the system and the heavy burden it placed on the national economy made continuance of the full system much more difficult to justify. To maintain the entire system as a stabilization device to protect consumers in poor harvest years would be a very expensive proposition. The attempt since 1978 to lower overall costs by restricting ration coverage to the lower half of the population was an important step toward improving the efficiency of the system. The fact that this politically sensitive change was accomplished is a development that few would have considered possible a short time ago. It is also a commentary on Sri Lanka's administrative sophistication, itself a reflection of the successful levels of social development achieved.

Costs and Aggregate Benefits

Government cost. The most visible cost involved is the loss the government takes on the distribution of subsidized commodities plus

the operating costs of the agencies involved. In the case of the domestically procured rice, the government distribution loss arises from the difference between the procurement price paid to the farmer and the price at which grain is sold to the consumer. For imported commodities, it originates in the difference between the import price converted at the official exchange rate and the ration price. When the procurement price is above the world price (at the going exchange rate), the fiscal cost rises in good crop years when more of the rationed rice is produced in Sri Lanka, and falls in bad ones when the opposite is true. The gross and net costs to the government of operating the food subsidy schemes in Sri Lanka from 1967 to 1975 appear in Table 1.

Table 1—Gross and net fiscal food subsidies, 1967 to 1975

Year	Gross National Product	Rice Subsidy	Distribution Charge	Total Rice Subsidy	Other Food Subsidies	Sugar and Flour Profit	Net Food Subsidy With Distribution Charges
				(million Rs)			
1967	8,264	424.6	34.6[a]	459.2	3.6	260.6	202.2
1968	9,876	530.2	37.6[a]	567.8	10.9	280.5	298.2
1969	10,725	545.3	51.8[a]	597.1	14.0	288.5	322.6
1970	11,562	505.6	48.5[a]	554.1	14.5	313.5	226.5
1971	11,786	474.8	47.1[b]	521.9	4.2	286.8	239.3
1972	12,616	468.7	36.7[b]	505.4	21.6	224.8	302.2
1973	15,168	498.7	41.8[b]	540.5	25.9	201.8	364.6
1974	19,694	635.6	66.0[b]	701.6	34.6	22.6	713.7
1975	21,935	718.8	41.5[b]	760.3	11.9	−164.0	936.2

Sources: For gross national product, International Monetary Fund, *International Financial Statistics Yearbook 1979* (Washington, D.C.: IMF, 1979). The other columns are IFPRI estimates. Inter-agency transactions within the public sector have been subtracted from them.

[a]Imputed.

[b]Estimates from the Central Bank of Ceylon, *Annual Report* 1967-75 (Colombo: Central Bank of Ceylon, 1967-75).

During much of the history of the operation, income from the sale of sugar and wheat flour, particularly sugar, was enough to offset a major part of the cost of the rice subsidy. In 1969-70, for example, gains on the sale of sugar and wheat flour (Rs 285 million) were equivalent to almost 53 percent of the rice subsidy cost. Up to 1973, the net cost of the subsidy remained relatively stable. In 1973, however, the gain from wheat flour turned into a large operating loss as import prices rose. In 1974 the gross rice subsidy rose sharply with higher rice import prices, and the sugar offset dropped drastically as world sugar prices mounted. The combined result was that the net subsidy cost tripled between 1973 and 1975. The largest contribution to this increase was higher sugar prices.

The net subsidy during most of the period considered amounted to slightly more than 3 percent of the gross domestic product. However, the cost burden appears much worse when the restricted financial means of the government are taken into account. In the five-year period 1964/65 to 1968/69, the net subsidy averaged 14 percent of total current account expenditures. In the three-year period 1969/70 to 1971/72, this figure dropped to 10 percent, but jumped to 18 percent in 1975 in spite of major cutbacks. Pathmanathan estimated that the subsidy was equivalent to 36 percent of public sector capital expenditures in the 1965-70 period, and in some years exceeded 50 percent.

Thus a very large portion of the government's disposable resources had been absorbed by the subsidies. Excluding the exceedingly high cost years after 1974, the net rice subsidy in the years 1967 to 1973 was 12.5 percent of gross domestic capital formation.

Other costs. The above cost estimates understate the real burden, however. In the early 1960s exchange controls were introduced into Sri Lanka and have continued ever since with only a brief respite in the late 1960s. Under the Foreign Exchange Entitlement Certificates Scheme (FEECS), significant portions of the nonfood imports were made at the FEECS rate at a premium of 44 percent above the official exchange rate, while food imports continued to be made at the old rate. By 1972 the premium increased to 65 percent. By 1978, 60 percent of the current payments were being routed through the scheme, but imports of rice, flour and sugar were never invoiced at the FEECS rate. This means of financing the system held down the direct burden on the budget by transferring it to other segments of the economy, particularly the export sector.

In Table 2 the FEECS exchange rate was used to obtain an alternative estimate of the subsidy with rice valued at its import price converted at the FEECS rate. The subsidy to the consumer is the difference between what he would have had to pay for rice he consumed at the world price equivalent at FEEC rates and what he actually paid. By subtracting the total subsidy at the official rate from the hypothetical subsidy, an estimate of the "hidden tax cum private subsidy" involved with the operation of the program was obtained (see last column). In the crisis years of 1974 and 1975, the hidden tax involved was very large, and the amounts give a better indication than the cash subsidies of the degree to which consumers were protected by the distribution system during those years. The burden of the hidden tax was borne by exporters and by consumers of import substitutes.

Distribution of benefits. Table 2 shows the distribution of gross benefits from the rice subsidy among rice producers and consumers. The value of rice used is its import price converted at the official exchange rate (columns 1-3) and at the FEECS rate (columns 4-6). Using the official exchange rate, producers received a large proportion of the benefits in some years and 60 percent of all bene-

Table 2 —Distribution of the aggregate rice subsidy between rice producers and consumers, 1965 to 1976

Year/Average	Official Exchange Rate			FEECS Exchange Rate[a]			
	Producer Subsidy	Consumer Subsidy	Total Subsidy	Producer Subsidy	Consumer Subsidy	Total Subsidy	Private Net Transfer[b]
				(million Rs)			
1965	154	195	349	28	479	507	158
1966	185	187	373	26	476	502	129
1967	241	163	404	29	470	499	96
1968	41	479	520	−341	997	655	136
1969	205	268	473	−142	754	611	98
1970	389	88	478	−22	598	576	131
1971	387	58	445	108	468	576	132
1972	360	11	371	127	377	503	237
1973	159	304	463	−384	1,084	700	449
1974	276	438	714	−1,555	2,718	1,163	622
1975	461	135	595	−452	1,670	1,218	474
1976	744	252	492	−209	1,176	967	139
1965-73 average	236	184	431	−63	634	506	174
1965-76 average	300	165	473	−232	858	658	234

Source: IFPRI estimates.

Note: The FEECS is the Foreign Exchange Entitlement Certificate Scheme.

[a]For years before 1968, the premium of 44 percent was used.

[b]Private net transfer is equal to the total rice subsidy at the FEECS exchange rate less the total subsidy at the official exchange rate. The latter is an estimate of fiscal subsidy.

fits during the 1965-76 period. This is because the domestic procurement price was kept above the import price (at the official exchange rate) during much of the period. In 1972, when the import price was low, the consumer subsidy component was only Rs 11 million, whereas the producer subsidy was Rs 360 million. This raises serious doubt about whether the public distribution system was primarily a consumer-oriented system at all. At the FEECS rate, however, the system appears strongly biased toward consumers. Farmers were net beneficiaries in only 5 out of 12 years in which world prices were very low.

Which of the two estimates is more realistic? Because the general foreign exchange situation in Sri Lanka was not as serious before 1965, paddy farmers as well as consumers appear to have received a substantial subsidy from the scheme. In the very high world price years of 1974-76, the system was heavily biased against farmers and toward consumers. In the interim period, from 1965 to 1973, it seems reasonable to assume that the true exchange rate was somewhere between the two values. This implies that the scheme was approximately neutral or slightly favorable to rice farmers and represented a large net subsidy to consumers.

The subsidy as a proportion of income in the low-income groups, and its impact on the relative distribution of real incomes, were significant. As we have seen, the lower-income deciles received as much as 16 percent of their real incomes from the rice ration. Inclusion of the value of the ration subsidy in individual incomes lowers the Gini coefficient of income inequality from 0.29 to 0.22. The income redistribution effects are especially significant if one takes into consideration the extreme administrative and political difficulties of extending aid to low-income groups in other types of programs. It can also be argued that the income distribution effect of the food distribution system was larger than these estimates might indicate because of indirect effects on employment and returns to labor.

The system as a whole has had an important effect on the rice economy. The high guaranteed prices for rice helped to stimulate production, while the operation of the ration system played an important role in expanding the demand for rice. The rice paddy sector has been responsible for a large proportion of employment growth. According to one authority about 30 percent of the total increase in employment between 1946 and 1960 was provided by rice/paddy production. Because much of the increase in purchasing power from the ration is spent on other foodstuffs and rural products, the total employment impact in rural areas was still larger. For the bottom 30 percent of the population, 41 cents of every additional rupee of income goes to non-cereal foods, particularly meat, fish, milk, eggs, sugar, oil, nuts, and other foods that are traditionally labor-intensive activities. Another 8 cents of the rupee of increased expenditure went to housing, and 10 cents to clothing, much of which was probably labor-intensive and locally produced. The comparatively small rural-urban income differentials in Sri Lanka, no doubt, are in part a reflection of these developments.

It is not clear what role can be ascribed to the ration in this process, and to what extent the same results could have been achieved by price supports without the ration, or by other means. There seems to be little doubt that the ration played an important practical role. The need to supply the ration system provided a strong incentive to maintain the procurement system which was the basis for providing high prices for farmers. The ration helped small farmers to participate in the expansion process by permitting them to dispose of a larger quota of rice at the procurement price and get cash to purchase inputs. The price policy might not have been politically feasible without the ration. There is some question whether without the ration the domestic demand for rice would have been able to absorb the amount of rice produced domestically in the 1960s, especially toward the end of the decade. At a higher rice price to consumers, imported wheat would undoubtedly have occupied a more important place in the diet.

Discussion of Costs and Benefits

The real measure of the cost of the public food distribution system should be the impact on long-term growth. Efficiency losses due to price distortions result in lower real incomes and reduced savings. Probably more important, the drain on public resources lowers government investment in directly productive assets, while financing the budget competes for private investment resources. The measures presented earlier, such as subsidy outlay as a proportion of domestic capital formation, suggest that this impact may have been substantial. The possible impact on growth via the balance of payments constraint is difficult to assess because of the offsetting influences of the disincentive to export of the overvalued exchange rate and the contribution of increased rice production to foreign exchange saving.

A full appraisal should also take into account the positive relationship between operation of the system and economic growth. The welfare programs in general, and the rice subsidy programs in particular, should have contributed to increased productivity of investment in Sri Lanka by augmenting human capital. There is also reason to believe that raising the real incomes of the poor has been instrumental in stimulating rural development and mobilizing local resources that would otherwise have been underutilized.

Unfortunately, there seems to be no objective basis, at present, for quantifying these various effects. The long-term growth of per capita income in Sri Lanka, although not comparable with that of the most rapidly growing Asian economies, was nevertheless respectable. During the 1960s, GDP grew 4.6 percent per year. In the postwar period, however, Sri Lanka has not grown rapidly enough to prevent levels of unemployment from rising rapidly, especially among the younger age groups. And there seems to be little doubt that the rising cost of operating the food distribution system in the 1970s contributed to poor economic performance. From 1974 to 1977 gross domestic product was stagnant. This was an unusual period, however. The consequences of passing on the full rise in costs to consumers would have been socially and politically unacceptable during the crisis years, and a good case can be made that having the public system in place was instrumental in avoiding still more widespread hardship.

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ENERGY CHOICES

ILLUSTRATION OF THREE TYPES
OF ENERGY: FIREWOOD, COLLECTED
BY HAND; ENERGY FROM THE
SUN; AND ELECTRIC POWER, SUPPLIED
FROM OIL OR COAL GENERATORS.

Energy Sources and Technologies: Hard Choices

R. Thomas Hoffmann and Brian Johnson

[This article describes the kinds of complicated choices among alternative energy technologies that Third World policy makers must confront in today's world of scientific change and partial knowledge. (Previous energy topics in the Development Digest were: July 1976, pp. 51-86; April 1977, pp. 85-124; and July 1979, pp. 3-52.)]

One of the biggest problems facing both developed country aid programs and developing country governments as they set up new energy programs is to get the fullest use out of existing resources that are both limited and constrained. This might be called the problem of "targetry," which refers to the series of choices among alternative investment opportunities, aid subsidies, and technological options that are made, whether consciously or by unconscious bias, before any allocation of resources can be decided upon.

The complexity of decisions on energy is illustrated by the case of Mali--in fact, a whole range of difficult energy aid choices is illustrated by the concentration of donor country interest in this large, but sparsely populated, desert and semiarid Saharan country. The European Development Fund (EDF--the fast-growing concessional aid program of the European Community) and the U.S. Agency for International Development (AID) have established quite opposite strategies to help ease Mali's acute firewood and oil crisis. The EDF has set up a considerable number of solar energy demonstration projects using irrigation pumps powered by photovoltaic cells which produce electri-

Mr. Hoffmann is the General Counsel of the International Institute of Environment and Development (IIED), Washington. Mr. Johnson is a Senior Fellow with IIED, London.

city from sunlight. The EDF's representatives in Mali want a highly visible program using the most reliable solar water pumping equipment available. They are installing relatively expensive $50,000 pumps designed for use by an entire village; and, in addition, the photovoltaic cells are costly and esoteric. The philosophy is that these very low-maintenance, trouble-free units can have a considerable impact on crop irrigation and water supply in the villages. Certainly this approach has attracted publicity and interested the Malian government.

The American energy project in Mali takes an entirely different approach, proceeding in four research and application phases over a period of several years. It includes an overall evaluation of socio-economic factors and villager preferences, as well as research on biogas and solar-powered irrigation. The project is primarily designed to gather and analyze information, rather than to have an immediate effect on the needs of villagers. The eventual goal is described as providing a technical and data foundation for future work of AID and the government, so that larger scale projects can be properly planned and executed.

Not surprisingly, each aid agency has considerable reservations about the other's approach. They appear, superficially, to be not only incompatible but mutually frustrating. But it is possible that *both* approaches are appropriate in the same country at the same time. To attack the energy problems of a country like Mali on the needed scale, political and popular support needs to be generated at every level. Hopes for a better future--the belief that problems are solvable--must be fired. This means early and tangible results. The EDF effort serves these purposes. The AID project will excite only a few energy and development planners, but it should provide the knowledge on which to base sound project ideas and fit them into a well-conceived energy planning effort. The challenge is to gather behind both approaches the momentum, conviction, and funding needed to make an appreciable difference.

The differences in approach of these two aid programs in Mali also point to one of the significant barriers to improving energy supply and use in the Third World. A false perception of choices frequently springs from the view that one type of energy is more (or less) appropriate to all the developing world needs. Thus there are advocates of nuclear power, of solar energy, of biomass, and of hydrogen fuel. These advocates concentrate on energy technologies rather than on the particular needs that energy fills. This narrowness becomes even more troublesome because of the often made, but simplistic, assumption that financial resources are somehow fungible,

or transferable from expenditures on one type of energy technology to another. For example, the EDF's program in Mali is spending large sums on the most sophisticated and expensive form of solar energy, photovoltaic cells, to help a limited number of villages. It could be argued that these funds might be better spent on a much larger number of firewood projects. This might *ideally* be true, but in fact the money is only available because this type of project promotes an expanding European solar energy industry which needs subsidized markets to get off the ground. Indeed, the Malian example shows clearly how widely professional opinions can differ on ways of focusing effort and allocating investment.

This article addresses that problem of targetry. It examines present attitudes toward the availability of, and the problems with, some energy sources for which there are substantial expectations in the Third World. We do not discuss all the energy sources available for developing country application; because our focus is North-South cooperation, we concentrate on the technologies and energy sources that are most susceptible to transfer by the "North" (i.e., the industrialized aid-giving and investing countries). For example, we pay little attention here to the potential for biomass fuels, even though they are surely one of the most promising options for quite a few developing countries, because biomass programs involve relatively small capital investment and no transfer of sophisticated technology from North to South. Biomass programs can largely be carried out by Third World countries on their own, without foreign help--although there is probably a great deal of scope for technical cooperation among developing countries.

What, then, are the energy sources available to Third World countries with which Western help and advice is most likely to make a difference? We start with the energy source whose shortage has captured the world's attention.

Oil

The production potential of the great majority of countries dependent on oil imports has been explored superficially at best: enough to determine that large, easily exploitable reserves are not present, but not enough to establish whether there are smaller deposits that could make an important contribution to national energy supplies. If oil is not looked for, it certainly will not be found. The reasons for this state of affairs are discussed below, but first it is important to survey the conditions that dominate oil use in many developing countries.

Both the international and the local purchase of oil are subsidized directly or indirectly in most developing countries. Oil-

importing developing countries (OIDCs) buy much of their oil on international credit that they cannot hope to repay in the forseeable future. And within many of these countries, consumer purchase of oil products, particularly kerosene, is also subsidized by the national government. The reason for this state of affairs says much about the Third World outlook on oil demand. In developed countries it is increasingly accepted that we are approaching the *end* of the oil era. But many developing countries--at least the majority of those who before 1973 had begun to anticipate the amenities of cheap energy in their lives--were only entering the oil era. Their transition into petroleum-based economies has been slowed dramatically, however, and now the question remains whether pricing policies and other incentives can be rethought quickly enough to make it feasible to avoid heavy oil dependence wherever possible.

In practice, the imperatives of immediate need are arrayed against the long-range negative pressures, particularly because oil supply and price projections have always underestimated the impact of political events. OIDCs suffer most in times of crisis; some of the poorest countries cannot meet their minimal needs when world demand soars, and the spot markets are often unavailable to them simply because of their lack of ready cash. On top of this, the Third World is not organized to allocate oil among its needy countries, a problem that the North attempted to solve for itself by creating the International Energy Agency. The distribution of OPEC oil is still carried out largely by major international oil companies, but since 1975 many smaller-scale buyers (such as refineries and traders) have dealt directly with OPEC producers. Most of the poorer countries still have almost no protection against being bypassed altogether by tankers headed for Northern ports--although in mid-1979, Saudi Arabia claimed to have earmarked a small production increase for sale exclusively in OIDCs, at the established Saudi price. Finally, oil prices in many areas of the Third World, particularly rural areas, are often several times those of the United States or Europe due to inadequate ports and roads, and transport costs can double or triple the effective price for a barrel.

The scale of recent discoveries in Mexico highlighted the possibilities for fossil fuel recovery in some developing countries. But the more significant breakthrough may be the recovery of previously unexploited or undiscovered reserves for domestic use on a comparatively small scale now that the higher oil prices could justify higher unit costs. The World Bank estimates that as many as thirty-eight oil-importing countries have reserves sufficient to make a very significant difference in the availability of oil for their own domestic consumption. Why have these reserves not been developed in the past? One of the main reasons is that international oil companies have had little incentive to carry out the expen-

sive exploratory operations that precede production at prices prevailing earlier, and in areas of cost uncertainty. In Africa, for example, this can be attributed both to political circumstances (a general wariness of political instability and possible nationalization) and to geography (oil produced away from the coast is difficult and expensive to transport). In Latin America, on the other hand, some countries with known reserves have been extremely protective of their development. One South American country, for example, appears to have substantial undeveloped reserves. In the early seventies, concessions were leased to a dozen or so major oil companies; but the government imposed such unpalatable restrictions--such as harsh financial penalties for insufficient exploratory drilling--that most of the companies faced an absurd choice: if preparatory work indicated a halt to operations, they would either have to pay large fines or drill useless wells in difficult, largely jungle, conditions. Only recently, however, the one company that stayed on made major discoveries, and others may now be attracted to return since a new government has come to power. But five years' delay is probably costing that country millions of dollars in lost foreign exchange spent for imported oil.

Oil exploration is a risky business. Major companies usually try to spread the risk among entrepreneurs (e.g., in joint ventures) and subcontractors. But in the case of the poorest countries, this has been impossible because of the absence of the financial and scientific capability for exploration. Another significant blockage to oil development in the Third World can be traced to domestic political priorities. For example, the price of oil at the wellhead in at least one case has been tightly controlled in order to subsidize domestic prices for consumers. In addition, the national oil company has held all the best concessions for years but done little with them. These two conditions have totally blocked any serious international exploration or production activity, even though the country spends much of its export earnings on imported oil.

Of course, the greatest deterrent has been that the international price fetched before 1973 made small-scale deposits or those in remote locations entirely noncompetitive, and even known deposits were usually left in the ground by the major oil companies. In theory, a developing country could hire exploration services, buy equipment, and contract for technical services to develop its oil resources. But in practice, the challenges of such an undertaking have, till now, proved insurmountable. The major companies have not had exclusive control over oil recovery technology; their advantage has lain in concentrating on management, knowledge, capacity to hire skills, and marketing networks--capacities that give them the ability to organize and coordinate huge and integrated technical and financial operations. Now, the present and prospective price of oil

may offer remarkable opportunities for creative entrepreneurship in mobilizing national or regional enterprises to explore for small oil deposits in neglected areas.

Electricity

The benefits of electricity need hardly be reiterated. There are two principal limitations on the contribution of electricity to development: cost and access. Electricity is already far too expensive to be purchased by the truly needy. It has been estimated that the costs of new electrical generating and transmission capacity to supply the equivalent of one daily barrel of oil are $37,000 for electricity produced from fossil fuel and $46,000 for nuclear or hydroelectricity. In 1977 electricity prices in developing countries were two to four times typical consumer prices in the U.S. and Europe. Despite these difficulties, electrification in both the city and the countryside is, ordinarily, a priority goal of almost all Third World countries. Three large-scale sources of electricity are available: hydroelectric, fossil fuel, and nuclear.

Hydropower. Although oil dominates the commercial energy market in the Third World, hydroelectric power projects have long known favor with development financing agencies. Many great dams were planned and built during the 1960s. By the time of the oil embargo, most of the obvious locations for large-scale projects, near population and industrial centers, had been developed. The oil price rises of the 1970s, however, have changed the economics of hydroelectric power drastically, so that higher transmission costs from remote river basins have become justifiable. A renewed interest in hydropower has surfaced in the last three years, although the lead times and construction period for hydroelectric dams are long, so that the impact has not yet been fully felt.

Changing attitudes toward rural development must, however, be taken into account in examining potential cost advantages for hydroelectric development. In the last decade development planning has come to reflect a new level of concern for the broad social and environmental consequences of development. For example, in some development assistance agencies planners now look for the most desirable development opportunities in a river basin, rather than simply assuming that a large dam in the best alternative. With the return to favor of hydroelectric power, there is a danger that environmental consequences will once again be overlooked under countervailing economic considerations. Environmental factors such as heavy siltation of a reservoir have, in the past, ruined major projects, literally undermining the initial investment. But major dam schemes are currently under construction in Africa and elsewhere that ignore almost every lesson that should have been learned from the environmental disasters associated with the large dams of the 1960s.

Decisions to plan and finance many more large dams reflect the habitual methods of major construction and engineering projects in the Western industrialized countries more than they reflect fresh analysis of the real needs of developing country populations. This in part explains why, despite a good deal of talk, so little serious attention has been given to the prospects for small hydroelectric projects. Exploitation of the remaining potential for hydroelectric production will be subjected to delay roughly in proportion to the scale of the project due to the heavy initial capital costs and the time required to prepare a hydroelectric plan for financing. Moreover, as the best remaining sites for large schemes are located in mountainous areas, generally far from population centers, transmission costs will tend to show smaller hydro schemes to further advantage.

Larger hydroelectric facilities will continue to be competitive for industrial and urban markets, and potentially very valuable as the centerpiece of the integrated agricultural and industrial development, for example, of a river basin region. However, smaller markets and isolated rural areas can be served by smaller dams. There are myriad sites in developing countries suitable for medium to very small hydro installations. In a brief review of the distribution of population in Tanzania, it was reported that a surprisingly large proportion of Tanzanians live close to year-round streams. Tanzania is generally a dry country, so it is not unreasonable to suppose the same findings are likely to be true of some other developing countries with the same conditions.

Small-scale hydro or other water-control projects need as much careful environmental attention as large barrages. Jamaica, for example, has a program for building over 200 microdams for mini-hydropower generation and irrigation; but five of the six built in the project's initial plan failed to hold water because the bedrock of the valley, which was limestone, had been insufficiently surveyed, and the floodwater simply disappeared into the porous rock. The Chinese, on the other hand, have been able to provide some of the electricity for three-quarters of their rural communes with mini-hydro generators, and there seems to be no reason why many developing countries should not achieve far more than is even contemplated at present.

Coal. Unlike much of the developed world, which largely shifted its energy dependence from coal to oil in the fifties and sixties, the developing world has always generated most of its electricity with oil-fired power plants. With the continuing rise in oil prices, however, prospects for widespread coal use seem to be on the rise. This is true in spite of widespread warnings in the scientific community over the probable impact of increased coal use on the atmos-

phere and the world's climate from increased carbon dioxide emission; most experts agree that these issues call for careful scrutiny. Many are convinced, nonetheless, that coal is the best available "transitional" fuel; that is, coal could be used in place of oil while renewable energy sources are being gradually developed and applied.

It certainly looks as if enough coal is *physically* available to accomplish this task. Known world coal reserves are about five times as large as known oil reserves. Most of these *known* reserves are found in the United States, the Soviet Union, and China with only 3 percent of presently known coal deposits in non-communist developing countries. In the developing world, only India has large known reserves, though Botswana, Brazil, Indonesia, and Swaziland are also thought to have substantial coal deposits. Very little of this coal in the Third World is mined and used. India mines significant amounts of it, but is joined only by Yugoslavia, the Republic of Korea, and Turkey.

Very little is really known about the potential for coal production in the Third World, primarily because there has been so little exploration for coal and, as with oil, most developing countries lack sufficiently detailed geological data. No worldwide rush has developed to locate and mine coal deposits in Third World countries, although coal is still much cheaper than oil particularly when compared in terms of the value of heat content. This situation prevails both because private companies have not been attracted by coal's price, and also because coal is more difficult and expensive to transport than oil. The United States or the Soviet Union might become major coal exporters to the Third World. That development has not begun to happen, in part because a large capital investment would be needed to switch to coal use in developing countries. Coal-fired power plants would, however, meet developing country needs for reliability and flexibility in size and they can be easily adapted to growing electricity demand without disrupting the entire distribution system. In short, the changing politics and price of oil make almost every eventuality seem within the bounds of possibility.

It would be very difficult to promote the expanded development of coal in Third World countries at the moment, because the demand to buy the coal does not exist. The World Bank has conducted one of the few reviews of constraints to coal use, and concluded that a large effort would be needed to promote longer range energy planning (allowing for the long lead times to develop coal resources) and to create the needed institutional and technical expertise, which is now almost totally missing. Finally, unlike the expanded use of some other fuels, enlarged interest in coal in the Third World may depend, in great part, on trends in the developed countries. Without an assured demand for coal, perhaps in Western Europe or Japan, there will be no

export opportunities; and without research and development work in the North, there are unlikely to be any technical innovations that would be applicable in developing countries.

Nuclear power. In the early 1970s hopes for nuclear energy as a potential source of electric power in developing countries were very great. The International Atomic Energy Agency (IAEA) published *A Market Survey for Nuclear Power in Developing Countries* in 1974, which estimated that 140 reactors could be sold to Third World countries in the years 1981-1989. In May 1976 the IEA halved that estimate, and six months later officials were privately admitting that the estimate had been quartered.

Commercial nuclear power stations are operating in only six developing countries today, and in most respects nuclear power is ill suited to the foreseeable needs of almost all developing countries. Nuclear plants smaller than 200 megawatts are simply not available, yet very few developing countries have national electric grids that can accommodate plants larger than 200 megawatts, because stable electricity distribution requires that no more than 15 percent of the power come from any one generating station. Nuclear power plant construction is one of the most capital-intensive undertakings in the world today, and the return on investment lies years in the future.

In the short run, the nuclear industry fosters nearly total reliance on developed country supplies and technology. Most developing countries are now plagued by large balance of payments deficits, and they fear the political ramifications of external reliance for energy supply, yet virtually all of the equipment and the fuel for nuclear power must be imported, even by nations with indigenous uranium resources. In Iran, for example, even cement had to be imported from Germany because no cement manufacturer in Iran could provide materials that met minimum stress standards for safety purposes. A few of the most scientifically advanced developing countries, like Argentina, India, and Brazil, have advancing nuclear programs based on local capabilities. But it is clear that the immense export subsidy programs provided to nuclear plant manufacturers in the industrialized countries have been designed without particular regard to the needs or the financial predicament of much of the potential "market."

Electricity Distribution. Rural access to centrally generated electricity is still negligible in many areas. Only about 4 percent of rural Africans and 23 percent of rural Latin Americans are able to have electricity. Although most developing countries have become genuinely alarmed at the migration of rural populations to the cities, their energy distribution policies continue to encourage this trend.

The proclivities of most development aid agencies do not provide a countering influence.

Electrical power can be provided to potential rural consumers in one of three ways: central station electrical grids could be extended to reach them; small, decentralized generators using conventional fuels could be installed; or electrical systems using locally available renewable resources could be installed. As of 1975 over 80 percent of rural electricity was supplied from central station grids, for which the capital costs are much higher than for decentralized systems. The decentralized approaches improve access, but they can dramatically increase operating and maintenance costs. When the system is heavily utilized, the capital-intensive centralized approach is strongly favored over the fuel-intensive, decentralized approach. Moreover, once a grid is in place, the marginal costs of expanding service to nearby centers of demand are often relatively low. Indeed, such expansion may lower system-wide unit costs, thus serving as a strong stimulus for increasing the generating capacity.

The cost comparisons are reversed, however, for service areas remote from existing networks, due to the large costs of transmission links and "line-losses" of electricity. Rural electrification programs should not be discontinued. But transmission lines are now so expensive (in 1976 a 400-kw line cost more than $80,000 per mile) that it is questionable in a number of cases whether the benefits of centralized rural electrification would survive the rigorous economic analysis to which the benefits of decentralized, renewable energy sources are now subjected.

Centrally based power projects are, of course, essential for modern industrial growth. Most aid agency commitments to rural electrification programs have not been reconsidered, partly because of the political importance of pledges to electrify rural areas in many Third World countries. The situation in India is not atypical: the electricity that reaches villages there is rarely purchased by more than 20 percent of the households. In these circumstances, the future of traditional approaches to rural electrification, long considered so vital to agricultural productivity, has come under increasing challenge. However, commitment to alternatives has not taken hold.

Solar Energy

Much has been promised for the "technologies of the future," most of which take energy more or less directly from the sun. Is solar energy a practical solution to the energy problems of the Third World? The question is not easily answered, particularly because it is often misconstrued, but interest in the possibilities of solar energy is growing extremely rapidly in North and South alike. The Tata Energy

Research Institute in India has conducted a survey that found more than sixty-three countries and nine international organizations carrying out solar research and development programs. During the fiscal year 1979, the U.S. Department of Energy spent $500 million on solar research and increased that amount by about 50 percent in 1980. The world's second biggest solar spender, France, allocated over 260 million francs ($62 million) in 1978 to solar research and development. Finally, investment in solar energy now looks sufficiently attractive that the interest of major international companies, particularly the oil industry, has recently been awakened, so that many small solar companies have been acquired by much larger firms.

Certain solar energy applications for developing countries have clearly failed to meet the hopes of their promoters. Continuous efforts with solar cookers in various places have never really taken hold. The technology was unfamiliar, it was not possible to design it for use within existing lifestyles because cooking had to take place at an unpopular time of day and at an unaccustomed slow rate, and as a result the experiment is now generally regarded as a failure. Likewise, a French solar hot-plate company made an early effort to distribute irrigation pumps powered by solar thermal collectors through the French aid program in the Sahel and in Mexico. The problems with this heat-collecting device have been severe, particularly because the motors driven by the solar heat often break down under tough rural conditions. The director of the Latin American Office of the United Nations Environment Programme said of the Mexican project that it had been "very profitable for the French and costly to the Mexicans. It does not generate employment; there is increasing dependency on foreign technologies; it is capital-intensive; and contrary to the long life expected, in less than five years of operation, out of thirteen plants, only one is in operation."

Expectations about solar energy derive almost entirely from how one perceives its eventual applications at some point in the future, and this has been a highly controversial subject in the developed countries. Northern argumentation over the best way to develop solar energy has three consequences for potential use in the Third World. First, it means that the debate over solar energy centers on the question, "When will solar electricity be competitive with other sources?" That question, and much of the analysis that pursues it, tends to assume that competing sources of energy are *available or affordable* under Third World conditions and that they will continue to be available in the future. For example, animal muscle power to pump water may be the only alternative to solar pumps. But one must consider the environmental as well as economic costs of keeping the necessary cattle at work. Where fuelwood is almost exhausted, one must also consider the environmental and economic costs of burning dung instead of using it for fertilizer, and so forth. Likewise,

extensions from electricity grids are only prohibitively costly in rural Third World areas if one assumes very low consumption levels; but if one does not assume low consumption levels, one ignores the relative poverty of the potential purchasers and the small amounts of electrical energy they may actually demand.

This leads to the second misconception that has been fostered. Sometimes costs appear exorbitant because of the level of energy use that is assumed. For example, running a flashlight on dry-cell batteries is extremely expensive in "dollars per watt," but is in fact tolerably cheap because only a couple of watts are used and flashlights are very useful for certain specific purposes. In the same way, water from solar-powered irrigation pumps may be "expensive" today; but this expense may be justified as a necessary part of an investment in research and development, in the same way that many dollars were spent on nuclear research technology before the first commercially viable reactor was linked to an electricity grid. There may be no alternative to solar-powered irrigation for the foreseeable future that is in fact affordable and available for meeting minimal water needs in remote areas. If so, then innovative demonstration and application tests to find reliable equipment are needed.

Third, solar energy projects are evaluated with methods that are often deficient with respect to Third World use. Traditional economic cost-benefit analysis assigns a value only to benefits for which a direct monetary value can be calculated. But the application of a solar energy technology in a remote area should not be compared to its theoretical competition, but to its *actual* competition. Thus, it should be a substantial "benefit" that energy will be available where it would not have been for some time to come if other sources were awaited. Another gap in the present system is the absence of field testing organized to adapt new technologies in light of local resources, activities, and energy needs. Products intended to use solar energy technology have not been designed for local conditions in poor countries, neither the power sources themselves nor solar-powered products like refrigerators. This causes good opportunities to be missed. For example, an important opportunity for international solar marketing today is in hot water heaters for the rich in tropical and semitropical countries--including the tourist industry. Not only would rich consumers benefit, but conventional fuel consumption and hence all imports would of course be reduced. The new systems would be emulated within countries as fast as the middle class could afford it. Furthermore, the wealthy in poor countries own most industries; the sooner they become familiar with domestic solar benefits, the sooner they will start adapting their manufacturing.

A final problem can be traced to the difficulties encountered by large institutions such as aid agencies in recognizing and seizing

opportunities that require deviation from "business as usual." A few solar technologies for a few applications are competitive today in certain areas of the Third World where all the circumstances are right. And if the cost of photovoltaic cells drops as much by 1985 as is now widely predicted, the opportunities for this form of solar power may increase and diversify dramatically. The price of photovoltaic cells is measured in "peak watts," the output of a solar electric cell under the best possible conditions--noon on a sunny day. In 1979 a peak watt cost between $10 and $12 dollars; the 1985 price is predicted to be fifty cents. Once photovoltaic cells begin to enter the energy market, their toehold becomes an economic force that reaccelerates continued expansion of the market and continued reduction in price. The vexing problem, however, is locating the purchasing power that will unleash this cycle.

To summarize, many observers believe that there is a large potential market for solar energy technology in the Third World. Others are skeptical and stress that a market cannot exist among poor people who have no funds to pay for energy. Not only solar energy but renewable energy sources in general tend to be burdened by excessive optimism at this time, and also excessive suspicion arising from these opposed points of view. Optimism in some developing countries derives from an uncritical faith in technological advance. There is, again, no simple and obvious way ahead. But fortunately, a small but vocal minority of developers has come to advocate design, testing, demonstration, and adaptation in the region where energy technologies will be used. A substantial commitment to this process might go a long way toward dispelling another Third World suspicion--that developing countries are to be the proving ground of the North's future energy sources.

The Limits to Technological Solutions

Clearly no one energy source of technology will be right for every developing country, any more than this would be the case for an industrialized country. But aid-giving countries face a special problem in advising developing countries on how best to achieve the correct "mix" of energy sources for their particular circumstances because it can be extremely difficult to suspend developed country biases in offering this advice. It is rarely true that technological choices are obvious, so that the biases or values of whoever is choosing may be consequential.

For example, sharpening the focus of publicly financed programs must start with clear definitions of the target populations to be reached and of levels of improvement to be aimed at. A 1977 study of solar energy application in Tanzania led to the broad conclusions that each of five small-scale solar technologies that were studied

was able to compete with diesel generators or extensions from the electric grid, or would be able to do so within a few years. These conclusions have been criticized because the study assumed that the villagers would consume quite low levels of energy (1 kwh per person per day). Would energy projects modeled on this and similar studies have a big enough impact, and soon enough, to make village life sufficiently attractive to villagers? The criticism of the Tanzanian study implied that legitimate Third World aspirations for more energy-intensive lives were not being taken seriously. These criticisms may well be valid if one has resources adequate to provide comprehensive help to a region or country as a whole. But if available funds are limited, as they inevitably will be, then a developing country government must choose: Will it try to have a smaller incremental effect on the lives of many villages, or a startling impact on the lives of a few?

As these judgments are made, developed countries must take care not to impose their own perceptions of energy planning on developing countries. Many Third World countries have neither the knowledge nor the management skills and planning capacities to devise an energy strategy that mobilizes an appropriate mix of alternatives. It has therefore become conventional wisdom that developing countries need better data on their energy supply and demand, better information about the energy uses of the population, more sophisticated management structures and planning capabilities, and probably more sophisticated research capability. The point is rarely made that all of these needs are endemic to a total condition of underdevelopment, and that real progress cannot be achieved in one area significantly beyond progress in others. And so, while policymakers must establish alternatives among technological approaches, they must also establish priorities among the range of institutional support and planning activities that are possible. Both types of priorities should reflect the wide variation in local conditions among developing country energy needs and energy planning.

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Wood as Fuel

U.S. National Academy of Sciences-National Research Council

[Wood serves as the major fuel to the majority of rural dwellers in the Third World. The following article discusses the properties of firewood, plantations for its production, and considerations bearing on the management of fuelwood programs; it concludes with recommendations featuring research and testing of trees for local suitability and productivity. (Note: Five articles on forestry appear in Development Digest, October 1979, pp. 1-36.)]

Advantages of Wood as a Fuel

As underground fuels become more scarce and expensive, the importance of wood is increasing dramatically. This has catapulted tree-growing into the arena of world energy production. Trees, if better managed and utilized, could rapidly increase the energy available to developing countries; and this could be done fairly inexpensively, without masses of foreign exchange or technology. In many cases using unskilled workers who are already available and under-employed in countries with severe energy shortages would be an additional benefit. Further benefits in an improved environment may be hard to quantify but are likely to be substantial.

The major concern of most governments at present is to increase and conserve energy supplies. Since energy for rural development has become more of an issue, firewood is beginning to enter the mainstream of national and international priorities and policies. Now there is new regard for foresters,

Article based on a report by an ad hoc panel of the Advisory Committee on Technology Innovation, Board on Science and Technology for International Development, National Academy of Sciences-National Research Council, Washington, D.C.

and appreciation of the importance of their skills to a nation's present and to its future. Many government ministries other than forestry--for example, ministries of energy, agriculture, rural development, conservation, natural resources, and community services--have suddenly become interested in funding tree-growing. Development-assistance agencies have also shown a new awareness of the importance of trees. They are coming to realize, for example, that it may be pointless to worry about producing more food if there is no fuel to cook it with, and foolish to invest in costly irrigation projects if continual deforestation by firewood gatherers will silt up the dams and irrigation canals.

Both technicians and political leaders are beginning to recognize a need to integrate forestry into rural development in new ways. The U.S. Congress has directed the Agency for International Development (AID) to focus on forestry and firewood plantations in its rural development programs. The World Bank, in a recent forestry sector policy paper, announced its intention to increase its support for such activities as village woodlots, farm forestry, and environmental rehabilitation. And in Nairobi, an International Council for Research in Agroforestry has been set up, aimed at coordinating and stimulating efficient land use through combining wood and food production.

The World Bank calculates that, even with optimistic assumptions that wood-conserving stoves, biogas reactors and solar cookers will be used where available, an additional 20-25 million hectares of trees will need to be planted by the year 2000. That is 10 times more than will be achieved at the present rate of reforestation. Regional shortfalls, of course, may be more serious. According to the Club du Sahel, tree planting in the Sahelian zone of Africa must increase fiftyfold if the firewood demands for the year 2000 are to be met.

Wood can be grown where no fuel was produced before. It is renewable, and its production can be sustained. For example, the Indian neem tree, *Azadirachta indica*, introduced to the Accra Plains of Ghana early in this century, has been providing firewood to towns including Kumasi and to villages in many West African countries ever since; and the supply seems to be keeping up with demand as the neem is reseeded by bats that eat its fruit. Another example of sustained firewood production is the Paliparan area in the Philippines. In the early 1920s when *Leucaena leucocephala* was planted there, it was a green desert of the tough *Imperata* grass, a scourge of the tropics. Since then the area has been a productive energy forest, yielding 20 m^3 or more of firewood per hectare per year. Even today it is the main firewood supply for the city of Laguna and surrounding districts.

Wood can be a "self-reliant" fuel that requires little foreign exchange and is independent of the vagaries of international commerce. It does not demand a sophisticated distribution network; indeed, it is the most accessible form of energy for most rural populations in countries where it grows. It is a familiar fuel whose use requires few extension services, and it is also one of the cheapest sources of energy available. It is one of the few fuels that an individual can produce for himself. Near Mendi in Papua New Guinea, highland tribesmen plant *Casuarina oligodon* for firewood around community "long-houses" and in abandoned farmland. Although contact with this remote valley was made only in the last 20 years, today it is common to see tribesmen sitting beside the road surrounded by cords of firewood for sale (see photo below). Fuel-

Papua New Guinea. Southern Highland villagers with cords of *Casuarina oligodon* wood wait beside the road for passing trucks from nearby Mendi. (N. D. Vietmeyer)

wood can also provide export income. Kenya exports charcoal to Arabian Gulf nations, and Surinam regularly ships charcoal to northern Europe. This can, however, be a mixed blessing. Eastern Kenya, for instance, has been severely denuded by the demands for exports added to those for wood to fuel the area's cooking fires.

Fuelwood is not limited to household use. Large energy plantations are planned or already underway in the United States and many other countries to fuel machines such as:

- Electric generators;
- Railroad locomotives;
- Driers for fish, tobacco, lumber, grain, copra, and other agricultural products;
- Factories milling sugar, timber, or other new materials;
- Pottery, brick, charcoal, and limestone kilns; and
- Metal smelters.

The lumber and paper industries have long used by-product bark and waste to generate steam and electricity; 8 percent of Sweden's energy and 15 percent of Finland's energy is generated from wood. In the United States in 1974, more energy was generated from wood than from nuclear power. An electric generator designed to consume about 25,000 dry tons of wood fuel each month has recently been installed at the Jari Project in the Brazilian Amazon to power a pulp mill, a sawmill, and a township of over 10,000 people.

The government of the Philippines plans to support rural electrification with several wood-fueled power plants. Early in 1978 it planted an energy forest of *Leucaena leucocephala* which will be used to fuel a 75-megawatt steam power plant. A survey that covers hauling distances, plantation and cooling-water requirements, and available government reforestation areas has identified 25 potential energy plantation sites with a total area of approximately 320,000 hectares. If fully planted, these could support 19 wood-fired power plants with an overall generating capacity of 1,425 megawatts. According to the official report, a wood-fired electrical generating plant could compete economically with an oil-fired plant, and could generate an estimated net foreign exchange savings of approximately $146 million in the first 10 years of operation.

Firewood production can be good for economic development in rural areas. Growing trees for firewood can be successfully combined with the production of posts, poles, and timber. The production and sale of wood to nearby urban centers can provide many jobs and much rural cash income. It has been estimated that some 6,000 families are involved in supplying wood and charcoal to the city of Maputo in Mozambique, for example. Few other energy sources can provide and maintain such high employment.

Firewood Plantations

A logical first response to the firewood situation is to plant more trees. In theory, almost all countries have the physical re-

sources to meet their most urgent rural firewood needs. It has been estimated that at least 75 percent of tropical land is inherently unsuited to sustained conventional agriculture, but 35 percent of the population of the tropics lives on this land. About half of it will not support vegetation of any kind. The best use of the remainder often is tree cultivation, or the simultaneous or sequential cultivation of trees with annual crops, or with the pasturing of animals. Virtually everywhere, villages have unused or misused areas on which woodlots can be planted. But there is little modern experience with growing trees explicitly for firewood, even among most foresters. Fuel production has long been considered the lowest use of wood, and foresters have traditionally cultivated trees primarily for other purposes, such as for timber and pulpwood. For these products, the species they choose to grow are not those that would be grown purely for fuel. Moreover, the yield measurements reported, the management techniques devised, and the varieties selected almost never reflect potentials for firewood production.

Firewood plantings can use species with short boles, crooked trunks, or wood that warps or splits as it dries. These features are not as detrimental to fuelwood use as to timber production. Nor is stem size. In simple cookstoves, for example, branches as small as one or two centimeters in diameter may be ideal. Thus a low shrub may prove satisfactory for village fuelwood silviculture if it grows fast and produces a dense wood that burns with intense heat. In practice, fuelwood may come both as a primary crop from fuelwood forests and as a secondary crop from timber forests.

In 1936, horticulturists transported seed of *Calliandra calothyrsus*, a small Central American shrub, from Guatemala to Indonesia. They were interested in it as a shade tree and ornamental. But Indonesians took up *Calliandra calothyrsus* as a firewood crop instead. For 25 years fuelwood plantations of *Calliandra* have been established, until they now cover more than 30,000 hectares in Java. The wood, too small for lumber, is dense, burns well, and is ideally sized for domestic cooking. It is also useful for fueling brick, tile, and lime kilns, and for copra and tobacco driers. Indonesian villagers now cultivate it widely on their own land, often intercropping with food crops. The plant's value is illustrated by the village of Toyomarto in East Java where land that was once deforested and erosion-pocked is now covered with a *Calliandra* "forest" and is fertile once more. Today the villagers sell the firewood, earning more from it than from their food crops.

Another example of shrubs grown successfully for firewood is found in South Korea. The leguminous bushes *Lespedeza bicolor* and *L. thunberaii* rapidly cover bare ground, and their long, shallow roots bind and hold down soil. Prolific root nodules provide nitro-

gen, and their protein-rich foliage is fed to livestock. Foresters plant *Lespedeza* species around pine seedlings to protect the soil, to provide plant nutrients, and to produce forage and firewood until the pine forest is established. The dense wood of the small stems is used for cooking fuel, and it is a well-established Korean practice to plant *Lespedeza* species along ridges as a firewood crop. It can be harvested only a year after planting, yielding 2.9 tonnes (dry weight) of firewood per hectare, or 6.1 tonnes after 2 years. The flowers are a source of honey.

In addition to fuel, woodlots in and around villages and cities can provide stable and pleasant surroundings. They provide shade. shelter, beautification, and habitats for wildlife, which in many areas are a valued food source. The plantations also reduce wind erosion, beneficially influence local temperature and humidity, and in many cases replenish and redistribute essential soil nutrients. A covering of plants slows rainfall runoff, which generally allows for greater groundwater recharge and so helps maintain year-round stream flow. Thus it decreases the likelihood of floods and the buildup of silt in reservoirs, thereby increasing the capacity and life of hydroelectric and irrigation facilities. Reforesting denuded areas is a preventive measure that decreases the severity of flooding and decreases the load of sediment entering waterways. Growing trees or shrubs within watersheds also improves the water quality of rivers and lakes and the growth of fish and other aquatic foods.

Woody plants can provide more than fuel calories. They can also be sources of:

- Vegetable oil and fruits and nuts for food;
- Edible leaves and shoots for sauces, curries, salads, and beverages;
- Honey;
- Forage for livestock and silkworms;
- Green manure for fertilizing soil;
- Tanbark for the tannin used in leather making;
- Medicines and pharmaceuticals;
- Extractives such as resins, rubber, gums, and dyes;
- Timber, lumber, posts, poles, and pulp for paper, cardboard, and construction boards; and
- Shade for pastures or plantation crops such as coffee and cacao.

Some of these uses are inimical to fuel production, but they give the tree owner more flexibility; he has the option of using some specimens perhaps for forage, while keeping others for fuel. In times of hardship, he may sacrifice some tree growth to feed his

family or animals with the foliage. In some cases, dense forests can produce a great deal of burnable waste wood without a living tree being felled. In others, the owner may sell the best formed trees for timber or pulp and use the remainder for fuel.

Fuelwood Management

Firewood production is less dependent on silvicultural expertise than sawtimber is, and therefore can be undertaken by nonprofessionals who learn the basic techniques for their own use. Thousands of Brazilian farmers in São Paulo, Minas Gerais, and Paraná already grow eucalyptus woodlots, partly for firewood, on land generally unsuitable for agriculture. Although the cultivation of firewood species does not demand continuous professional supervision, a forest service may be needed to provide seed or planting stock of the most advantageous species, and advice for getting the trees established. Further, silvicultural practices (such as weeding and pest control) can greatly increase yields. What is sorely needed is the greater involvement of trained forestry experts in firewood production at all levels from the village woodlot to the national forest.

Rural areas can probably supply their own fuelwood from small, local plantings, while urban areas can best be supplied from concentrated large plantations, strategically located and possibly government administered. Firewood plantation, if carefully managed and protected from fire, animals, and "poachers," can be self-renewing. They are usually managed on rotations of about 10 years (much less in some moist tropical regions). The timing varies with the quality of the soil, species used, temperature, moisture available, and intensity of cultivation. Rotations of less than 5 years seem feasible in many areas, especially for those species that coppice, that is, that grow back from roots after being cut down.

Trees most likely to prove useful for fuelwood plantations are those called "pioneers," which in nature colonize deforested areas. These withstand degraded soils, exposure to wind, and drought. Many are rapid-growing legumes that fix atmospheric nitrogen. The very nature of a pioneer species endows it with adaptability, aggressiveness, and hardiness on hostile terrain. The most promising such species are often the last natives to survive repeated grazing, cutting, fire, and soil degradation. These are usually well known, available nearby, obviously adapted, and tough. Some of these species may not require nursery production and laborious transplanting. Some pioneer species can be seeded directly on site; large stands of *Leucaena leucocephala* and *Sesbania grandiflora* have been established in Southeast Asia merely by scattering seed from the air. At the

same time, the aggressive vigor and adaptability of some of these pioneer species make them potential weeds.

The ability to coppice, or grow rapidly from root suckers, is exceptionally important in a firewood species. The stumps of coppicing plants do not die; instead, dormant or adventitious buds regenerate new shoots. This allows repeated harvest without the cost and effort of replanting seedlings each time. Moreover, the living roots continue to bind the soil, and a canopy of new foliage quickly develops to shield the soil surface from rain and wind and to help suppress weeds. Coppice sprouts usually grow vigorously because they are served by roots big enough to feed the former tree. The continual cropping of coppice regrowth was an established technique in Europe in Roman times, and "coppice farms" were widespread in medieval England. Today eucalyptus pulpwood plantations, in Brazil and elsewhere, are based on coppice regrowth. The first crop (grown from seedlings) is usually harvested after 7 or 8 years; subsequent harvests (the result of coppice growth) are on 5- to 6-year rotations. In Europe and the United States, large tracts of redwood, aspen, maple, beech, and ash are grown on coppice rotations.

Most woods burn, but there are properties that differentiate their relative value for fuel. Density is the most general gauge of a wood's burning quality. The heavier the wood (when dry), the greater its calorific value. The heat given off is enhanced (by about 20 percent) by the resins found in conifer woods, and by the oils and gums sometimes found in hardwoods. Green wood has a lower heating value than dry wood because energy is used in evaporating the moisture. The loss may reach 20 percent, which represents the wastage of 1 growing year in every 5. Air drying the wood yields more calories per unit of time than does tree growth in the forest, and is therefore a critical firewood conservation measure.

Coppice Farming, England. Lime *(Tilia cordata)* coppice, Groton Wood, Suffolk. (O. Rackham and J. McCann).

Some woods burn well even when green, a particularly important advantage where fuel is so urgently needed that the users are unlikely to take the time to dry their firewood. Some woods are poor fuels for use in unsophisticated stoves because they spark excessively or because their smoke is odorous, toxic, or irritating. For the foreseeable future in developing countries, fuelwood will be hand harvested. Therefore, when choosing a species for firewood plantations, one consideration should be the ease with which it can be transported. Crooked and thorny species are difficult or bulky to transport, though for local village use this may be unimportant.

Implementation

Planting fuelwood on a large scale demands social and political commitment. Decision makers in some countries, including Nepal, South Korea, the Philippines, and the Sahelian countries, are already funding national tree-growing programs. But elsewhere the pending crisis is generally not attracting the necessary financial commitment. This neglect is likely to disrupt energy supplies and lead to severe hardship in rural areas. As the pressures for fuel increase, it may lead to civil unrest and the devastation of new plantations. Research on appropriate species and management methods should start before the crisis is reached. The forest services have a crucial role to play in this race against time.

What is needed is a change in priorities in the use of trained foresters *and* agronomists. Forest for fuel can be treated as just one more farm crop. This makes firewood production more suitable for developing countries with few foresters. It seems possible that existing conventional extension agents, trained as agronomists rather than foresters, will be responsible for much of the small-scale firewood production in the future.

The existing forests, however, are too important and too vulnerable to be abandoned by foresters in favor of village woodlots in the farm lands. It has been suggested that what is needed are paraprofessional "barefoot foresters" (corresponding to China's "barefoot doctors") to persuade small farmers, whose economic horizons may extend only to the next harvest, to plant trees for the future; to teach how to do it; and to introduce cook stoves that conserve firewood (see following article). Such extension services are particularly important in the case of individual and village-level fuelwood projects. Even with finances available, poor management and inadequate extension work are often critical bottlenecks. The accomplishments in South Korea have demonstrated the importance of having such trained people working at the village level.

To be successful, fuelwood programs should fit into the social and cultural framework of the local area where plantations are to

be established. Projects are often doomed from the outset by religious or cultural taboos, resistance to change, attitudes toward property ownership, or government intervention. Without the commitment of local residents to the orderly management and protection of the fuelwood plantings, they are likely to fail. Projects that demand basic changes in lifestyle are more likely to fail than those that adapt to existing lifestyles and outlooks. Further, as a practical matter, fuelwood plantings are more likely to succeed if they are considered in the context of local land-use planning and local development objectives. The integration of fuelwood production with other agricultural activities can help ensure and sustain local interest; it can also cut costs and balance the development of local communities by providing them with an energy supply.

Local communities must be motivated to assume responsibility for the management of all vegetation, including trees, in their area. Forestry departments in some African countries, for example, have been producing millions of tree seedlings for distribution to villages at subsidized prices, or even free of charge, hoping to encourage individuals and communities to plant more trees. But they have met with major success only in Ethiopia, where an estimated 50,000-100,000 hectares of eucalyptus have been established--almost all of it before Ethiopia had a professional forestry service--and all planted by illiterate but self-motivated peasants.

Recommendations

1. Firewood research is vital so that the most suitable and productive tree species be found and tested for particular locations.

2. The wasteful use of available fuel should be reduced. Harvesting practices should be analyzed and reformed where needed. The testing and developing of fuel-efficient stoves, particularly ones that villagers can make themselves, is also important.

3. Conserving existing fuelwood sources is critical, for example by controlling harvesting intensity to preserve forest productivity.

4. A systematic effort should be made to identify available production areas in existing forests, wastelands, and farmlands. In each area chosen for support, foresters should prepare an inventory of the tree species found locally, noting especially the species traditionally preferred for fuel.

5. Testing tree growth in all the available production areas. Tests should include:

- Optimizing growth of volunteer trees (self-sown) of acceptable fuelwood species;
- Test planting the best native fuelwoods; and
- Test planting selected exotic species. In all trials of exotic species, local species must be included for comparison.

Characteristics of the trees that should be assessed include growth rates by volume and dry weight (of stem and branch wood), wood and chemical properties, and resistance to pests. The importance of selecting and using the best seed source within a species cannot be overemphasized.

For species that show promise, adaptability trials should be set up to determine the responses of various species to different soils, growing conditions, altitudes, latitudes, temperatures, moisture conditions, and pests. This will indicate the relative advantages and limitations of each and will provide the technical backup for pilot-sized fuelwood plantations that can serve as demonstration plots. It will also enable researchers and officials to become familiar with the species tested. These trials might also provide the germplasm to start local woodlots and firewood plantations. Comparison of experiences from such pilot plantations will provide the foundation for decisions establishing and utilizing firewood plantations and allow predictions of economic success. Most of the species selected are likely to be grown mainly in woodlots and backyards or planted to double as living fences, or shade trees in pastures, or in plantations of coffee, cacao, or other crops. Testing should therefore be done over a range of such conditions.

[Extracted from Chapter I, Firewood Crops: Shrub and Tree Species for Energy Production, National Academy Press, Washington, D.C.]

Note: Most pages of this publication are devoted to detailed descriptions of tree species most useful for firewood; lists of books and articles on selected subjects are included. This publication can be obtained without cost by writing:

Board on Science and Technology
for International Development (JH-215)
2101 Constitution Avenue
Washington, D.C. 20418, U.S.A.

Stove Design for Efficient Wood Burning

U.S. National Academy of Sciences-National
Research Council, and Volunteers in
Technical Assistance

[Compounding the problem of fuelwood scarcity is the waste from inefficient fuelwood consumption. Improvements in the designs of stoves could have a significant positive impact on fuelwood supplies if widely distributed and used. The following article discusses and illustrates some of the more promising improved designs.]

Another approach to dealing with the scarcity of fuelwood in developing countries, in addition to planting more trees and better forest management, is to reduce the demand for firewood through introduction of more efficient burning equipment. The possibilities of this approach seem particularly attractive because firewood is most scarce in those regions of the world where it is also burned most inefficiently.

Roughly 80 percent of the fuelwood consumed in developing countries is used for domestic purposes: cooking, space heating, and hot water. Many traditional cooking stoves and open fireplaces waste wood mainly because they focus the flames poorly on the cooking surface. Improving wood-burning devices seems to be one of the best ways to alleviate the twin problems of firewood scarcity and forest depletion. Often, all that is required is a very minor redesigning of existing stoves.

Improved stove models are insulated to prevent heat loss through the walls. The hearth can be

Text from a report by an ad hoc advisory panel of the Advisory Committee on Technology Innovation, Board on Science and Technology for International Development, National Academy of Sciences-National Research Council, Washington, D.C.

closed to regulate air intake and improve combustion conditions. The flow of air and hot gases through the stove is directed to concentrate heat on the cooking surface. A chimney is usually incorporated into the design to provide draft, the motive power that provides air for combustion. (If poorly designed, however, chimneys can decrease efficiency by creating excessive draft.) Cooking pots are arranged to fit properly into holes prepared for them, preventing leaks and heat loss.

Improved stoves can probably achieve an overall efficiency of between 20 and 30 percent, and they have the potential for reducing wood requirements five- to tenfold. In addition to reducing the rates of cutting of the world's trees, the wide dissemination of such stoves could reduce the time, energy, and cash that Third World women now spend acquiring fuel and cooking. It will also help eliminate smoke-filled homes, sooty hands, and eye disorders caused by smoke and fumes.

However, the claims about efficient stove designs have seldom been substantiated in unequivocal tests. Therefore, it is important that any new stove be field tested on site before it is widely promoted for local use. Perhaps the best measure of performance is the weight of fuel needed to cook a number of typical meals. This result should be compared with those of other stoves, including traditional ones.

Many factors, other than efficiency, complicate the acceptability of any cooking stove: cost, availability of materials, size and type of wood available, family size, cooking practices, and types of dishes to be prepared. These vary greatly from region to region, which means that any given stove design may not be accepted or used efficiently outside the area where it was designed.

In many cases fuelwood savings can be realized even without changes in equipment. Perhaps the best way to do this is simply to dry or season wood before burning. When burned, moist wood produces less useful heat and more smoke. To ensure that wood is dry it should be split (in the case of large logs) and stored for 6 months. Since economic pressures often prevent proper seasoning of wood, carefully designed credit schemes to ease cash flow problems might enable the populations in developing countries to save millions of tons of firewood annually.

The following pages present a pictorial survey of designs currently in use that show promise of conserving fuelwood supplies if more widely distributed. The designs shown can be constructed from locally available materials and construction requires little technical expertise, so the technologies are easily transferred.

Indian Chulah

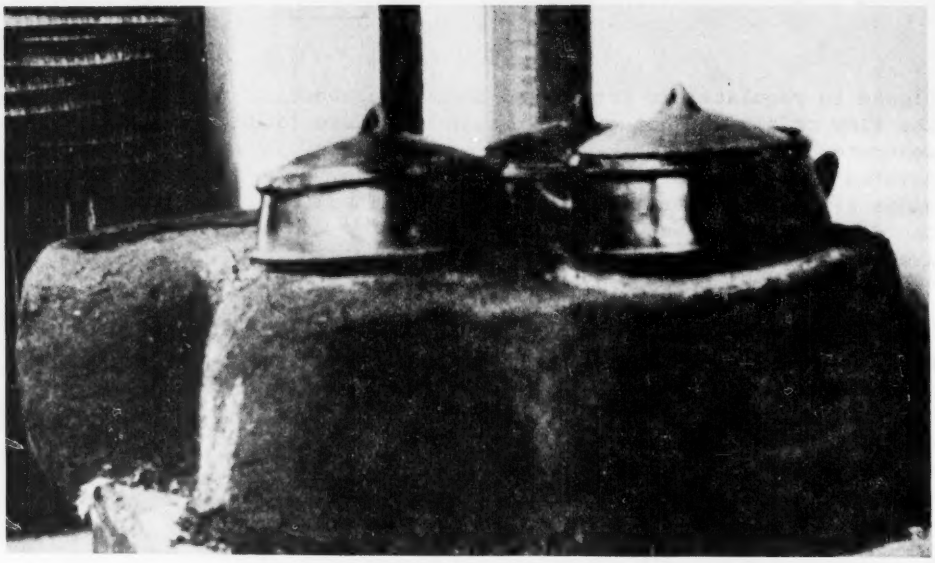


Photo: NAS

Indian Chulah. Named from the Hindi word for "cooking fireplace," the chulah has been the target of much research in India over the past 40 years. The chulah can be built of sand and clay to accommodate different sizes and numbers of cooking pots. Experiments with chulah have shown efficiencies as high as 30 percent. However, flue losses can be quite high and some tests have shown these stoves to use more fuel than their traditional counterparts that have no flues.

Ghanian Oven

Photo: NAS

Improved baking oven. In Ghana over 19,000 women operate small, wood-fired bake ovens and produce the bulk of the nation's bread. The traditional ovens are small, dome-shaped, built of sun-dried or fired-clay bricks, and take one layer of about 50 loaves. The University of Ghana Department of Nutrition and Food Science has recently found a simple way to double the stove's efficiency. Its oven has broken glass inside the base (to retain more heat) and is insulated with additional bricks. The most important modification, however, was a new construction technique that allowed the addition of a shelf so that the oven can accommodate a total of 100 loaves. This produces twice the quantity of bread for the same amount of fuelwood. (G. Campbell-Platt)

Roti Stove

Photo: NAS

The Roti stove. A seemingly efficient cooking system has been in use in the remote Indonesian islands of Roti and Sumba. The stoves are horizontal. Pots are hung in the flames so that the heated surface is exceptionally large: no heat is wasted up a flue–there is none.

Only one description of this cooking system has ever appeared in English. It is by Captain Cook (or perhaps by Sir Joseph Banks, as it appears in the 1773 Hawkesworth edition of *Cook's Journals*). This is how he described it:

"They dig a hollow under ground, in a horizontal direction, like a rabbit burrow, about two yards long, and opening into a hole at each end, one of which is large and the other small: by the large hole the fire is put in, and the small one serves for a draught. The earth over this burrow is perforated by circular holes, which communicate with the cavity below; and in these holes are set earthen pots, generally about three to each fire, which are large in the middle, and taper towards the bottom, so that the fire acts upon a large part of their surface. Each of these pots generally contains about eight or ten gallons, and it is surprising to see with how small a quantity of fire they may be kept boiling; a palm leaf or a dry stalk, thrust in now and then, is sufficient: in this manner they boil all their victuals, and make all their syrup and sugar."

Because of the quantity of heat transferred in this cooking system, meals can be cooked using palm fronds–a very poor fuel. The system certainly seems to warrant Captain Cook's enthusiasm and it deserves testing for possible use in villages everywhere. (J.J. Fox)

Korean Ondol System

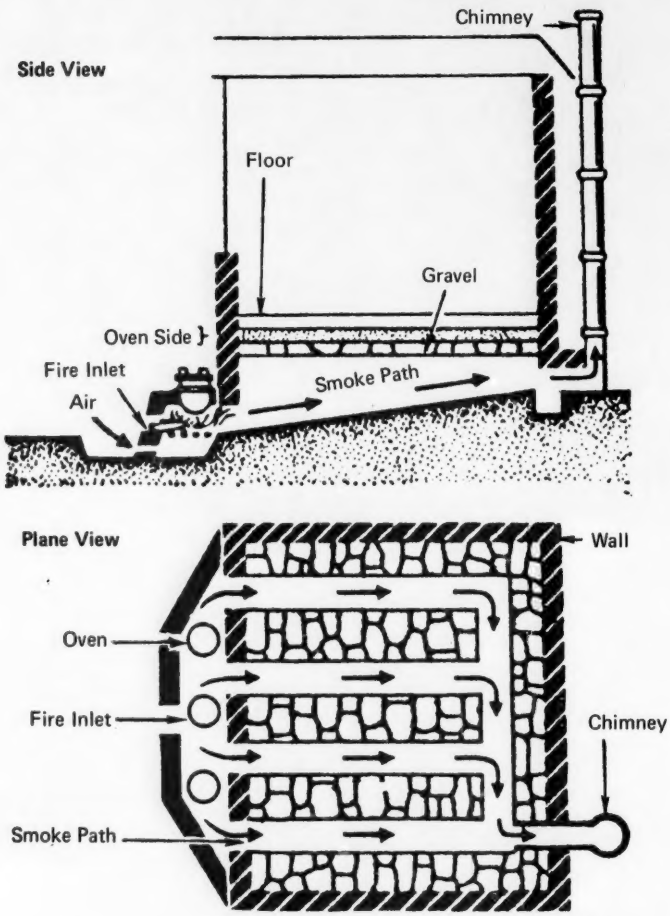


Diagram: NAS

Ondol system of cooking and heating. In the Korean countryside, houses are traditionally built over a labyrinth of clay pipes packed in sand that honeycomb the foundations. Heat and smoke from the kitchen fire, or from an outside furnace, passing through these "horizontal chimneys" warms the floor and thus the rooms above. Ondols are often fired with leaves, twigs, chopped wood, brush, or hay. The double use of the heat could serve as a model for use in other locations where both cooking and heating are needed. There is some hazard of carbon monoxide poisoning with this system if the floor allows the gas to move up into the house.

Lorena Stove

The Lorena stove, developed at the Estación Experimental Choqui, Quezaltenango, Guatemala, has attracted considerable attention around the world. Constructed of a mixture of clay and sand, the stove can be built for very low cost. The stove was designed by actively involving potential users. The stove greatly reduces the amount of fuel required, is designed to accommodate traditional cooking pots, and is built almost entirely of local materials.

A cottage industry has developed around the stove. Trained stovemakers have been able to make a living by building stoves in people's homes. In this way, and a variety of other promotion mechanisms, an estimated 2,000 stoves have been built in about 2 years. The Lorena design has been replicated or adapted in West Africa, Java, Nepal, the United States, and throughout Latin America.

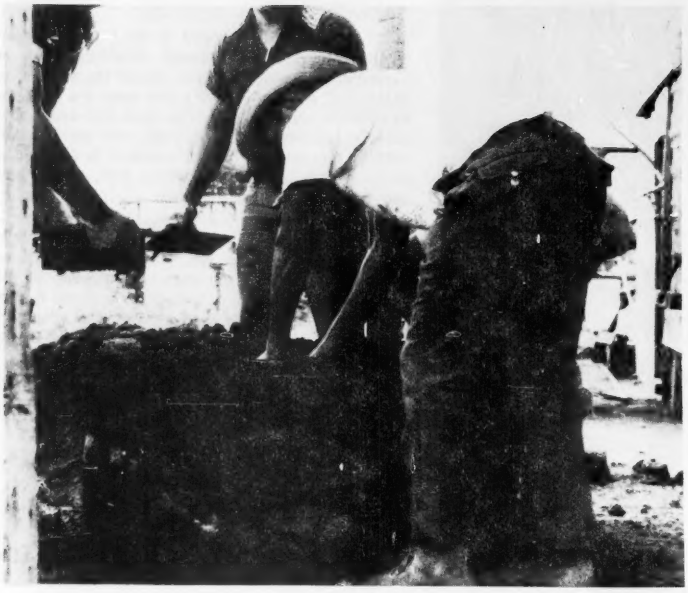
Photo: VITA File

Marina Garcia, promoter with the Choquí Experimental Station, Guatemala, cooking on her Lorena stove.

The following photographs illustrate a few of the steps in the construction of a Lorena stove.

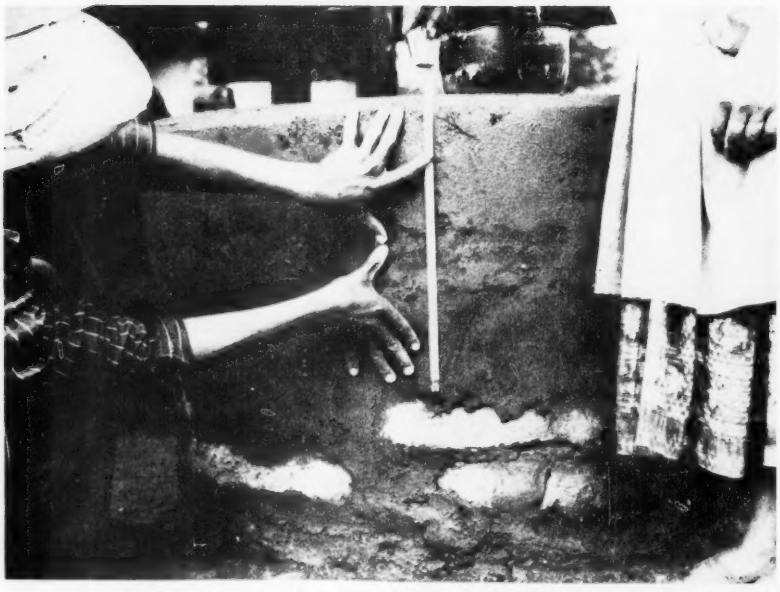
Arranging the pots to decide on the stove's size and design. The cook should participate in the designing process.

Photo: VITA File



Packing on the mixture of sand and clay called *lorena*.

Photo: VITA File

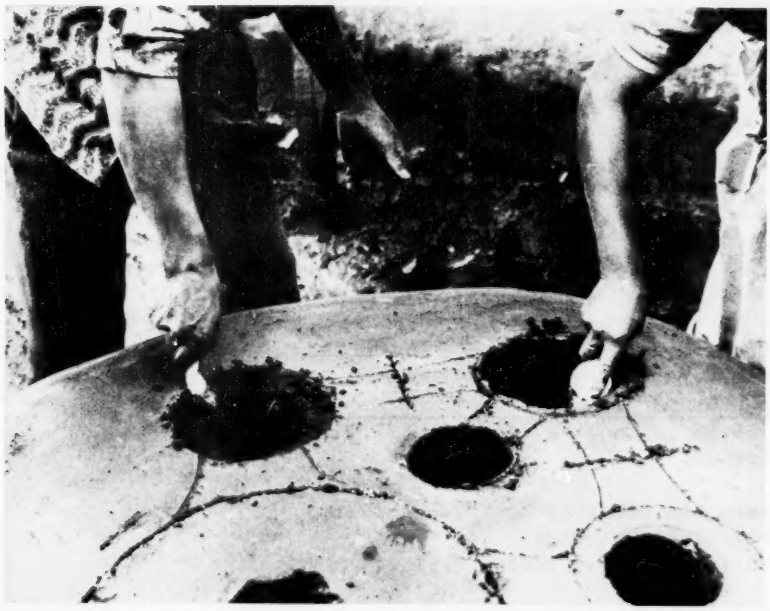


The height of the Lorena stove depends on the height of the cook, but the layers sand-and-clay need to be at least 40 cms. down from the top of the stove.

Photo: VITA File

The pots should fit the cooking holes exactly so that heat and smoke do not escape. Rotating the pots to be used during this stage of construction indicates where the *lorena* needs to be dug away.

Photo: VITA File



Potholes and flame ducts can be excavated with spoons.

Photo: VITA File

LORENA STOVE

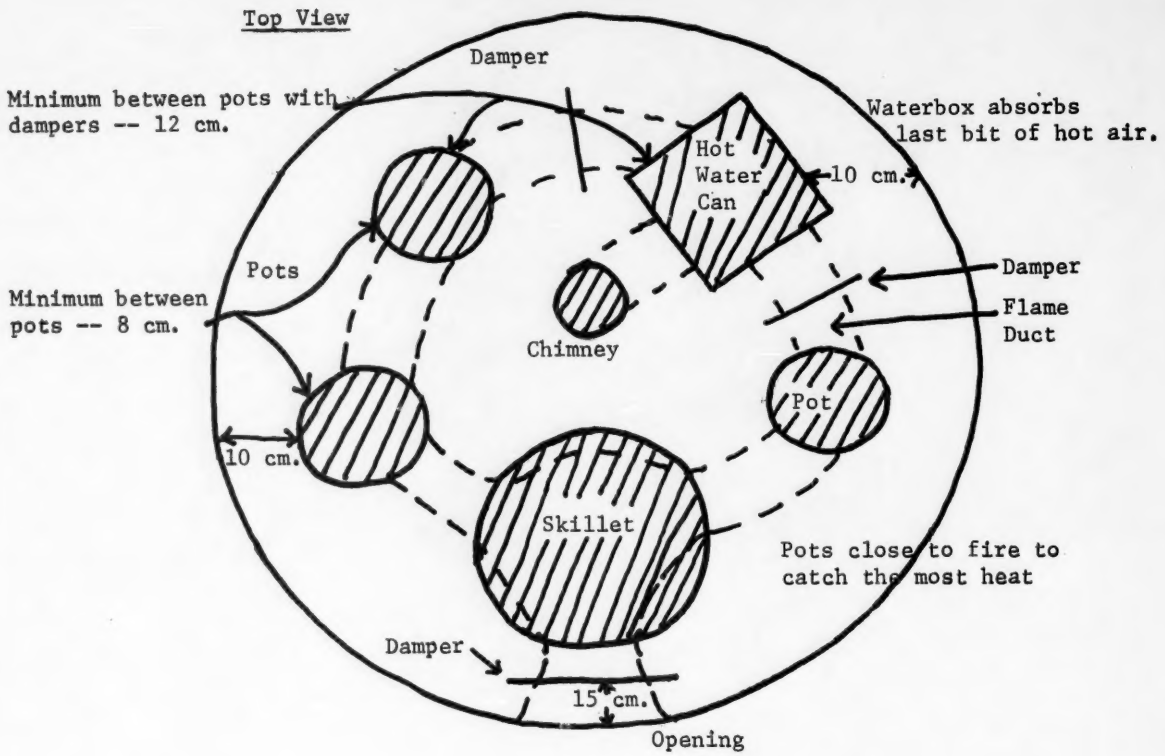


Diagram: VITA File

[Text and first four illustrations extracted from Appendix 1, Firewood Crops: Shrub and Tree Species for Energy Production, National Academy Press, Washington, D. C., 1980; Subsequent photos from "Lorena Stove Construction", (V-C-5, P1), Volunteers in Technical Assistance (VITA), Mt. Rainier, Maryland, 1981.]

Note: Further information on the use and construction of these and other woodstoves is available by writing to VITA. In addition, A Design Guide to Wood-Conserving Stoves is available at VITA for $8.95 in English, and for $12.95 in Spanish, Arabic and French.

Volunteers in Technical Assistance (VITA)
3706 Rhode Island Avenue
Mt. Rainier, Maryland 20822, U.S.A.

Peat as an Energy Source

D. V. Punwani

[This article describes peat: its varieties, abundance, and distribution; its value as an energy alternative; its current and future role as an energy alternative; and the environmental and socioeconomic impacts of large-scale peat utilization. Known peat resources have been found largely in northern areas, but tropical areas have been poorly explored.]

The importance of developing alternative energy sources to augment supplies of fossil fuels is growing all over the world. Coal, oil shale, tar sands, biomass, and solar, geothermal, nuclear, and hydroelectric power have received considerable attention as alternative energy sources. One large energy resource, however, has received little attention until recently. That resource is peat. Although peat is used as an energy source in countries such as Russia, Ireland, and Finland, it is virtually unexploited in many other countries.

What is Peat?

Peat is a heterogeneous material consisting of partially decomposed vegetable matter and inorganic minerals that have accumulated in a water-saturated environment over thousands of years. The remains of many common plants have been identified in peat: trees, heath shrubs, sedges, mosses, grasses, pondweeds, reeds, cattails, algae, and ferns. Under favorable conditions most of these plants multiply rapidly, and in some places large quantities of dead

Mr. Punwani is the Associate Director
of Chemical Processing Research,
Institute of Gas Technology,
Chicago, Illinois.

vegetation accumulate yearly. If this dead matter is exposed to air and aerobic bacteria, decomposition occurs without formation of peat. However, when the plant debris is protected from contact with air by immersion in water, peat is formed. This peat contains a substantial portion of the carbon and hydrogen of the original organic matter. Entrapment of peat by movement of the earth's crust may lead to extremely high pressures and temperatures, and the "coalification" process proceeds to form higher ranks of coal; peat is considered the first geological step in the formation of coal beds. The sequence starts with growing vegetation and proceeds to peat, lignite, bituminous coal, semianthracite, and anthracite to meta-anthracite or graphite. That is why peat is often described as "young coal."

The "coalification" process principally involves the removal of oxygen in the form of carbon dioxide and water. As a result, the concentration of combustible material (carbon and hydrogen) increases and the remaining material has an improved heating value. Because peat is formed in a water-saturated environment, peat as it occurs in nature contains about 90 percent water. The major components of peat and other coals that affect the combustion energy are fixed carbon, volatile matter, and oxygen. A comparison of the major components of peat with those of other coals is shown in Figure 1. The increase in

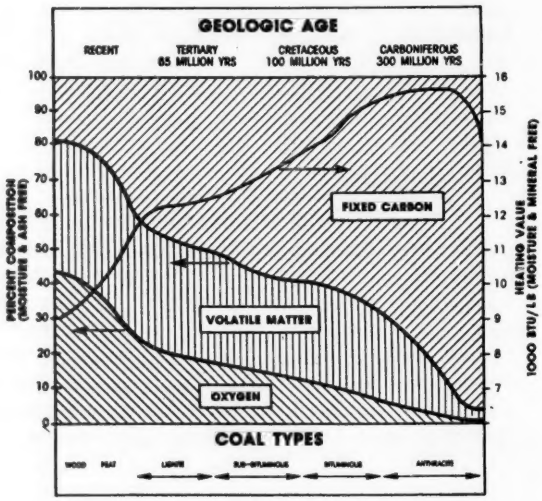


Figure 1. Comparison between peat and older coals.

Note: The line in Figure 1 which rises toward the upper right corner and has a right-pointing arrow shows heating values, measured on the right hand scale.

the fixed carbon is accompanied by reduction in volatile matter and oxygen content and generally with an increase in the fuel's heating value.

Varieties of Peat

The properties of peat vary depending upon the type of contributing vegetation and the degree of decomposition. The three most common categories are fibric (peat moss), hemic (reed-sedge), and sapric (humus).

Fibric peats are composed of sphagnum, hypnum, and other mosses. They are the least decomposed of the three types of peat and have the highest fiber content (minimum of 66.7% sphagnum moss fiber). Fibric peats also have a high water-retention capacity, low bulk density, and low ash content. Because they are the least decomposed form of peat, they have the lowest heating value on a dry and ash-free basis. Fibric peats are most desirable for horticultural use as soil conditioners, and least desirable as fuel peats for energy.

Hemic peats are formed from reeds, sedges, swamp plants, and trees. They have lower fiber content and are more decomposed than fibric peats. These peats have a higher heating value and lower water-retention capacity than fibric peats.

Sapric peats are composed of materials that have decomposed beyond botanical recognition. These peats are the oldest and most decomposed. On an ash-free basis the sapric peats have the highest energy content. The ash content of sapric peats varies from as low as 2% to as high as 60%, with high percentages reducing their energy value.

Peat Resources

Peat is a worldwide resource. A map of world peatlands is shown in Figure 2. About 95% of the world peat resources are found in Europe, the Soviet Union and North America. Estimates of peatland areas in the countries richest in peats are shown in Table 1. Surveys of peat resources throughout the world have been limited and vary considerably, partly because of differences among the methods used by various countries for reporting their peat resources. Some countries other than those listed in Table 1 might have deposits that are not large enough to substantially add to the total world resources, but are--nonetheless-significant to those countries and can still be considered valuable as energy resources. These countries include New Zealand, Argentina, Uruguay, Brazil, Paraguay, Iceland, Sri Lanka, and Burundi. Tropical areas of Africa, Indonesia, and Malaysia might also have large peat deposits.

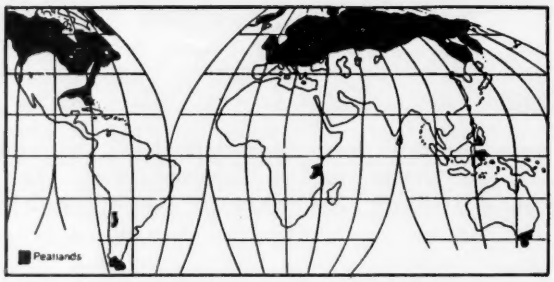


Figure 2. World peatlands.

Table 1. PROVEN RESOURCES OF PEAT

Country	Million Acres
U.S.S.R.	228.0
Canada	34.0
U.S.A.	52.6
Finland	35.6
Sweden	12.7
E-W Germany	13.1
Great Britain-Ireland	13.1
Poland	8.6
Norway	2.6
Indonesia-Malaysia	3.3
All Others	5.2
Total	408.8

Is Peat Economically Competitive?

Can peat be economically competitive with other energy alternatives even though it has a low heating value and low bulk density and may contain, in its natural state, about 90% water? Peat is now being commercially used in Russia, Ireland, and Finland. Soviet Russia has not just a few peat-fired electricity generation plants, but as many as 76, some of which have generating capacities exceeding 700 megawatts. Even though the economics of peat-fired power-generation plants in Russia is not known, it is assumed that using peat in these plants must be more economically favorable than bringing coal, oil, or gas into the areas of peat deposits. Russia is a net exporter of oil, gas, and coal; it is not experiencing a scarcity of these fuels that might otherwise force the use of peat even if it were not economically favorable.

In Ireland, peat has been used for electric power generation since 1950. About one-third of the total thermally generated electric power now is produced in peat-fired plants. Finland is by far the country most actively committed to increasing the commercial use of peat. Between 1975 and 1978, it increased its use of peat for energy tenfold. Eleven peat-fired boilers are in operation in Finland; their costs are competitive with oil-fired boilers. Because peat is a domestically available energy resource, it is preferred over oil, which must be imported.

Because newly dug peat contains about 90% water, it is impossible to burn. The heat required to evaporate the water is greater than the heat of combustion of the peat. However, if the peat moisture content can be reduced to 50% before combustion, the amount of heat required to evaporate the remaining water is only 12% of the available heat. Fortunately, the water contained in peat can be reduced to 50% moisture by exposing the wet peat to sun and air for a few days. Peat commercially harvested in Russia, Finland, and Ireland for electricity generation plants contains 35% to 55% moisture. Bechtel Power Corporation recently conducted a study for First Colony Farms on large-scale peat harvesting in the U.S. to support a 600-megawatt electricity generation plant. Results show that it is technically and economically feasible to produce peat containing 35% to 50% moisture using the air drying technique.

Peat has advantages over other coals that sometimes more than compensate for the disadvantage of being a lower grade fuel with smaller heat value per ton:

- Peat deposits are generally located in areas that have virtually no other significant fossil fuel deposits.
- Peat is not a physically hard material like coal and oil shale and it requires less sophisticated retrieval equipment.
- Peat deposits occur near the surface with little or no overburden, and the deposits are generally no deeper than 25 feet allowing greater accessibility.
- Peat is generally low in sulfur content, only about 0.2% compared with as much as 4% in some bituminous coals, reducing the pollution hazards involved in burning.
- Peat can be lower than coal in ash content.
- Peat has a high hydrogen-to-carbon ratio (even after accounting for the hydrogen that will react with the oxygen in the peat).

Recently efforts have been made to convert peat into a gas for transmission through a pipeline, as has been done experimentally with coal. The peat gasification work conducted at the Institute of Gas Technology under the sponsorship of the U.S. Department of Energy and Minnesota Gas Company shows that in several areas, peat compares favorably with coal.

- Peat has a higher tendency to make hydrocarbon gases (natural gas components) during the initial stage of gasification (when most of the volatile matter in peat reacts with hydrogen).

- The carbon remaining in the peat after the initial gasification stage is significantly more reactive than the carbon left after initial gasification of lignite and other coals.

- Peat has higher volatile matter and lower yield of hydrocarbon gases at relatively low hydrogen partial pressures.

- During the initial gasification stage (in the presence of hydrogen) the yield of gasoline-blending feedstock and fuel oil is significantly higher.

- Relative distribution between gas and oil yield can be attained over a wider range.

All of the above factors contribute to more favorable production efficiency and economics. Recent estimates also show that conversion of peat to high Btu gas (substitute for natural gas) is competitive with conversion of other fossil fuels to synthetic high-Btu gas. Therefore, peat can be an economical energy alternative depending upon regional energy needs, location of peat deposits, cost of other energy alternatives, and scale of operation.

Environmental Impacts

As with the development of any large-scale alternative energy resource, the environmental impacts of large-scale utilization of peat must also be evaluated. Environmental systems analyses indicate that peat harvesting techniques, local hydrology and water quality, and reclaimed land-use options are interrelated and that a comprehensive plan embracing all three of these areas should be formulated. The harvesting plan needs to include control of surface and groundwater flows throughout the project area.

Peatlands are wetlands and, because some unique biological species might exist in them, it might be desirable to preserve and protect at least some of those wetlands. But one of the benefits of a large-scale peat utilization program is that harvested peatlands can be used for crop production after peat is removed--unlike some coal lands which require costly reclamation.

The Future Prospects

The potential of peat as an alternative energy source is recognized in the United States where national and state governments and private companies are funding work in the areas of improved resource estimation, improved dewatering and harvesting technology, gasification process development, and environmental and socioeconomic impact assessment. Governments of Canada, Finland, Sweden, Iceland, Burundi, and Sri Lanka are also exploring the potential of utilizing their peat resources for energy. The overall objective of the current programs is to develop technology for using peat in an economical and environmentally acceptable manner. Increased exploration could make it possible to expand the known reserves into other areas of the world which would also benefit from this source of energy.

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Cultural and Equity Constraints Conditioning Energy Usage

Elizabeth Cecelski, Joy Dunkerley and William Ramsay

[Cultural preferences and issues of equity are often overlooked by technicians, aid donors and project administrators when tackling energy problems in the poorest parts of the world. The following article points out how these oversights have affected acceptance of energy technology, and therein provides a road map of pitfalls to avoid in future programs by seeking more information on consumer preferences and local situations before undertaking costly investments.]

There is evidence of a whole range of constraints which have inhibited the adoption of or limited the benefits from new economically and technologically feasible energy systems in the past, and which may do so in the future. This can occur even when the prices of new technologies that are prohibitively high have fallen to competitive levels. This article analyzes some of the factors affecting both the use and the supply of energy by the poor in developing countries.

While not as easy to quantify or analyze as strictly technical or economic aspects, these other parameters are of interest for two related reasons. First, unquantifiable costs and benefits appear to be important in assessing the value and impacts of projects in developing countries, just as they are in developed areas. And second, we can anticipate great difficulty or failures in the adoption of new energy technologies which do not directly match the energy demands and incomes of intended users, no matter how lavish the energy assistance program. Unfortunately,

Ms. Cecelski, formerly with Resources for the Future (RFF) is now a Senior Energy Adviser at Volunteers in Technical Assistance (VITA); Ms. Dunkerley and Mr. Ramsay are both Senior Fellows at RFF in Washington, D.C.

the information on these cultural and income distribution constraints on meeting the energy needs of the poor of the developing world is sparse and unreliable. These aspects of energy needs in developing countries have rarely been the subject of field tests or pilot programs. Information has become available only incidentally after the implementation of costly programs; thus, much of the record this analysis reviews is of failure. Less is known about the successes. Why did some technologies spread and not others? More research is clearly needed; in the meantime, this review draws on the available information in analyzing the effects of different frameworks of preference.

Cultural Preferences and Energy Use

Energy use in developing areas appears heavily conditioned by "cultural" habits or "tastes," as it is in developed countries. Traditional cultural rigidities are often cited as obstacles to change in developing societies; but the real problem is quite often an inadequate valuation by analysts of the non-monetary, or not immediately visible, amenities and disamenities associated with the introduction of new technologies. Thus, various energy sources will meet the demands for a particular type of heat, for convenience, and for religious or social meaning with different degrees of success. These needs will have different priorities depending upon the framework of preferences of local populations--partially but not entirely shaped by income levels.

Energy consumption habits which seem careless to outsiders may reflect an efficiency defined by local preferences. An energy system could provide numerous non-energy services--a pleasant smoky flavor in food if charcoal is the cooking fuel, or a symbolic social center for the family if an open fire is used. These traditional demands on energy systems are not only wider than engineering definitions of "cooking" or "heating"; they can also be more specific in demanding particular energy sources for special end uses. Among the Mbere in Kenya, for example, one type of wood is preferred for carrying a light from one place to another (a slow smoldering type), another for a quick light at night to tend a crying baby, another during the rainy season (one that will not become soggy and will dry out quickly), still another for the three-day slow brewing of the local millet beer, *marua*, and so on. In addition, the seemingly inefficient cooking fire may have a much higher total systems efficiency than it appears to have (even if only Btu outputs are counted) if the embers are used for space heating, the fire for boiling water for washing, and coals for cooking.

Cooking habits: the case of solar cookers. The role of cultural preferences in energy use in cooking warrants special attention for several reasons. Cooking accounts for a large proportion of energy use by the poor, and numerous attempts have been made to improve upon the low efficiencies of traditional fuels and stoves. An open

Income and Innovations

Income levels seem to be especially influential in the acceptance of new practices, governed by the extent to which people are able and willing to bear risks. A reluctance to abandon habits tested by generations of use is often justified, given the preferences of the local population. A new strain of wheat, for example, might be vastly more productive on average but not as resistant as traditional strains to drought or insect pests, which even if infrequent would be unsupportable in their impact on a poor farmer operating at the border of subsistence. In Tanzania, where planting at a single optimal time would maximize crop yields but rainfalls are highly variable, farmers prefer to spread planting over several weeks rather than risk losing their entire crop to drought. The "Green Revolution," which introduced high yielding varieties of grains into Asia in the 1960s, provides excellent examples of many of the cultural and equity problems of introducing new technologies in developing countries.

fire is reported to have an efficiency in Btu output/input of about 10 percent or less. The large element of personal and social involvement in food preparation, however, means that cultural factors play a conspicuous part in any alteration in energy use in cooking.

Solar cookers are a beautiful example of an energy assistance idea which foundered for lack of appreciation by energy planners of the cultural, "noneconomic" preferences of users--though, as is pointed out below, a more conventional economic reason (their relatively high price) may be sufficient explanation. The parabolic reflectors developed and manufactured in India in the early 1950s failed to gain acceptance because they reportedly required radical departures from traditional methods of cooking. Cooking outdoors in sunlit areas sometimes necessitates being inconveniently distant from dwellings, and in general can increase the exposure of food to dust, flies, birds and even monkeys, and not least the cook herself to the hot tropical sun. Being able to cook only in the daytime, where cooking is traditionally done before dawn or after dusk, cooking only one thing at a time, and having to adjust mirrors have frequently been cited as additional difficulties. Unfamiliar methods of cooking may also appear dangerous.

In Mexico, the University of Wisconsin attempted over a four-year period (1958-1961) to introduce 200 metallized plastic reflectors, focusing one kilowatt on the bottom of a cooking vessel, into three rural Mexican villages. Results were mixed. One report stated that even people who did not have enough food preferred buying kerosene to cook what food they had to using the solar cookers.

The problems reported included insufficient resistance to winds and rain, having to wear sunglasses to ward off glare, and unreliability of the sunshine. It has also been suggested that the existing local knowledge of American energy technologies made Mexicans reluctant to adopt a less "modern" energy source. On the other hand, some families used the cookers up to fourteen months, even though there was no evidence of scarcity of either wood or kerosene in the area. What limited success was achieved has been attributed by some to careful planning and long-term commitment by the University. In recognition of the importance of cultural factors in the introduction of such new cooking technologies, the use of cultural anthropologists has been recommended for such attempts in future.

Improved stoves. The introduction of more efficient stoves, using biomass or commercial fuels, has often met with problems similar to those of solar cookers--requiring unfamiliar methods of cooking and new utensils, appearing dangerous, and not matching the needs of the users. Improved wood stoves have reportedly been tested unsuccessfully in Indonesia, Guatemala, and India, and in a rural development project in Tanzania by the World Bank. One approach taken to the unfamiliarity problem has been to design more efficient stoves resembling traditional models. Appropriate Science and Technology for Rural Application (ASTRA), in Bangalore, India, has made marginal alterations in the traditional *chula* which increase fuel efficiency as much as three times, and is using highly visible demonstration projects in villages, accompanied by trained staff, to introduce the new stoves.

Biogas and waste disposal practice. Solar cookers and improved stoves are not alone among energy sources in potentially conflicting with established cultural practices and preferences. Virtually any new energy source for cooking requires changes in cooking habits--for example, electricity or biogas necessitate new stoves, and sometimes changes in utensils or cooking habits. The production of biogas, in particular, involves changes in cultural practices which in many regions are as fundamental as those involved in cooking. Psychological inhibitions against the use of "night soil" (human excrement) have been reported in Korea; a reluctance to use food cooked with gas from human wastes for religious worship, and pressure from elderly parents to disconnect toilets from biogas plants have all been noted in some parts of India; and Muslim opposition to the use of pig dung in generators has been cited in Indonesia.

In South Asia, the caste system may be a particular obstacle since it involves the delegation to certain groups of activities associated sociated with dirt and pollution. In some parts of India, for example, the *bhangi*--an untouchable caste--are responsible for herding swine along the roadsides near villages to clean up human and other wastes. *Bhangi* women are paid to gather human excreta from latrines in the homes of the more conservative villagers, where women in strict

purdah cannot leave the house. Contact with these wastes by members of other castes would make them polluted in a religious sense.

Experience of ill health effects of handling human wastes may lie at the basis of some of these reservations. A traditionalist doctor in Bali warned, for example, that sickness would result from using biogas plant slurry as fertilizer. While cow dung is considered to have pleasant cleansing properties by Hindus, and is in fact used as an insecticide and cleanser, human feces are known in India to be disease-ridden. The quantity of human wastes is small compared to that produced by cattle, but where cattle are scarce--as in Korea or Thailand--or for a poor family owning less than three or four cattle, latrines attached to small marginally economic biogas plants could make them viable. In China, however, night soil has been used for centuries as fertilizer; and human wastes are reportedly an important source of fuel for the new methane generators.

Summary. Different frameworks of "cultural" preferences have clearly played a part in the lack of acceptance of solar cookers, more fuel-efficient stoves, and biogas plants. These tastes or habits may define the parameters of potentially suitable energy sources. In some parts of the Sudan, for example, where breakfast is at ten and dinner at four, solar cookers may be more culturally appropriate than in India. Where cow dung is traditionally used as a fuel, as in India, methane digesters based on animal wastes have been an obvious choice. The possibilities for biogas plants using pig wastes will probably be limited in predominantly Muslim areas (but not many pigs are raised in such localities). In many cases, the identification for planners of specific priority energy and other needs of users, and choices among technologies made by users, could help prevent the introduction of energy devices that will not be used. In other cases, however, education has a role to play: while the Balinese doctor cited above, for example, has good reason to believe that spreading untreated human wastes on fields may spread disease, he is unaware that the slurry (processed digester by-product) from methane digesters carries no such dangers if properly treated.

However, it is not clear from the available evidence whether "cultural" resistance in cooking habits or use of wastes is or could be *the* key factor in the acceptance of solar cookers, more fuel-efficient cooking stoves and biogas plants. Cost, and the relative abundance of alternative fuel sources, appear to have been at least as important as cultural preferences in the failure of some solar cooker experiments, and possibly with biogas as well. Widespread commercialization efforts (rather than gifts) of solar cookers or more efficient stoves intended for the poor would require drastic decreases in their initial capital costs, whether or not the cultural constraints are important. Solar cookers may compete economically with other forms of energy only in areas such as Ouagadougou, Upper Volta, where fuel is very scarce and expensive; in such cases, cooking customs could change in response to strong enough economic incentives.

If costs can be reduced, the adaptability of traditional peoples to demonstrably superior ways of performing tasks and their response to economic and other incentives should not be underestimated. For example, private bank surveys in India of the reasons given for purchasing biogas plants have found that the clean-burning gas was preferred for cooking to the smoky flame given off by cow dung, which blackens the kitchen, utensils, and clothing, and can produce serious eye infections. On the other hand, people in developing countries are probably no more willing than those in developed areas to change habits they enjoy or find convenient in order to conserve energy or use it more efficiently. The real problem unfortunately may often have been that the new energy sources in question have really not been demonstrably superior, given the framework of preferences of local populations in developing countries.

Income Distribution and Equity in Energy Supply

High cost energy sources and the poor. Some energy technologies, while within the reach of some rural income groups, may simply be too expensive in any sense for the poor to afford. In other cases, by using life-cycle costing, poor consumers might actually be able to reduce their total energy expenditures in the long run by purchasing a more energy-efficient device, but are unable to do so because of the high initial cost of the investment--even though later costs might be very small. Rural electrification appears to be an example of the former, while some new renewable energy technologies exemplify the latter problem.

The introduction of electricity in developing countries illustrates particularly well the limitations of an exceedingly flexible but relatively expensive energy source in meeting household consumption needs of low income people. Most countries have viewed electrification both as a stimulus for irrigation or other agricultural or industrial development, and as a means of raising the standard of living of the masses of people in rural areas. Yet even though subsidized, electricity has not generally proven a suitable inexpensive energy source for household consumption by the poor, especially in rural areas where the marginal costs of hookups and electricity are high due to the dispersed and small-scale nature of demand. The household devices needed to use the electric current are also costly. Thus, only about 10 percent of the people in most electrified villages in India actually have electric hookups.

Even if the poor do not use electricity directly in households, they may still benefit indirectly as street lighting allows more nighttime activities, refrigeration in stores increases the availability of fresh produce and cold drinks, and health clinics are able to keep medical supplies refrigerated. However, where incomes are very low, electricity as a consumer good, unless heavily subsidized, is likely to be limited to a small group of the relatively well off. Therefore,

unless electricity is used for other, i.e., productive purposes, load factors will remain low, and the marginal costs high. An Indian survey of rural electrification in 1965 showed that growth in demand in villages slowed drastically after electric hookups were installed by some 20 percent of the population. A more recent survey in Comilla, Bangladesh, where electrification began in 1963,showed that even 15 years after the introduction of electricity, less than 5 percent of the rural population used electricity. This "saturation" level elsewhere may be greater or smaller than the 20 percent reported for India, depending upon income levels and other factors. But the possibility of such saturation should be an important consideration in allocating new investment to the expansion of existing rural electrification facilities, to the extent that electrification is intended to meet the household (rather than production) energy demand of the poor.

The newer types of energy systems tend to have low operating costs but relatively high capital costs. The Ghai solar cooker introduced in India, for example, costs $14-$18; but the traditional *chula*--a kind of earthenware bucket in which wood, dung, or charcoal is burnt and a pot set on top--has virtually zero capital cost as it is made from local clay. Although the long-term operating-plus-capital costs could possibly be lower for the Ghai cooker, life-cycle costing is often not a practicable concept for the poor, who cannot afford large expenditures even if fuel-use efficiency might thus be increased and total energy costs lowered. The same appears to be true of biogas plants, which in India cost Rs. 2,000 to 3,000 (about $260-$380); of more efficient stoves; and of reforestation programs, which necessitate both an initial investment and a significant deferral (10-15 years) of the use of fuelwood.

New energy technologies and access to other resources. A second potential equity problem is that the poor may be prevented from benefiting from new energy technologies because methods of dissemination, patterns of ownership, or local political power structures favor the relatively wealthy. The larger farmer can afford an electric hookup, which will run his tubewell and help him to increase the productivity of his fields; he can use the dung of his sufficiently numerous cattle to produce and sell methane gas; he can grow fuelwood on some of his land; and he can borrow capital against these resources. The possession of ample capital, land and cattle allows the wealthy farmer to benefit more than the lower-income population from any new technology.

In some cases, the condition of the poor may even be worsened by the introduction of energy sources susceptible to control by the wealthy. Biogas plants, for example, besides having a high capital cost, require a minimum of three to five cattle to produce the dung needed for their operation. Only wealthier farmers--in India perhaps 10 to 15 percent of the rural population--typically own that number. It has been reported that the average family in the State of Gujarat who owned a biogas plant also owned 10 hectares of land and 10 head of cattle; and the average annual income of most owners of biogas plants was $1,100.

Further problems relating to equity involve the money-pricing of goods which were previously "free" to the poor. Livestock customarily roam freely in India, providing a "free" source of dung for fuel to the poor who collect it. (It is free in the sense that the poor do not pay for dung in cash, although it has a real labor cost to them, and an opportunity cost to society as well since the dung could potentially be used as fertilizer.) Penning of cattle to collect their dung for methane generation by private owners in India could even increase energy costs to the poor; if dung assumes a monetary value as an input into a biogas plant, it is no longer "free" for the poor, who will also be unable to afford to pay for the plant's output of methane gas.

Similar equity problems may arise with fuelwood costs. In some developing areas, firewood has traditionally been virtually a free good. Deforestation, privatization of land, or institutional arrangements designed to control cutting in public preserves can deprive the poor of "free" wood, (except for their labor costs and ignoring environmental damage), forcing a shift to commercial markets. In Kenya, for example, land adjudication since 1970 has decreased the forest available to the public for cutting, as the new private owners of once communal lands have gradually restricted access by others, resulting in increasing the market sale of firewood. Commercial fuelwood plantations could have the same result.

Other decentralized energy technologies. Even apparently decentralized, "controllable" technologies such as photovoltaic cells (PVCs) may be just as inaccessible to the poor as is central grid electricity, since PVCs are not only very costly and capital-intensive, but are much too sophisticated to be manufactured in a developing country village. In one project in Mauritania, for example, a solar irrigation pump introduced by the French was controlled by two well-to-do members of the village, who sold the fresh water to poorer farmers who could previously draw free water from the well. In another example, while assisting a successful village cooperative to build water pumps and windmills in Tanzania, the head of the highly innovative Arusha Appropriate Technology Project admits that one can only hope that members of the coops--who are only a small portion of the population of the village, and not the poorest members--will use their new wealth to help others.

Conclusion

Clearly, different frameworks of preferences affect the ways energy is used, and patterns of income distribution influence the equity with which energy is supplied and the costs of providing new systems. If new energy sources are to be successfully introduced or old ones more effectively utilized, these considerations should play a much more important role in future energy assistance programs than they have in the past. Yet, it is also evident that funds are limited and time scarce; what sort of information is necessary in order to make intelligent decisions in this area?

One guide would be to start from the apparently technically and economically feasible energy sources--solar cookers in a few cases; biogas, wind and small hydro in appropriate areas; photovoltaic cells for some essential services; improved stoves, and woodlots--and try to determine what will be the role of different frameworks of preferences and the patterns of income distribution in their failures and successes, by initiating limited pilot programs. Indeed, if socio-economic feasibility were analyzed and treated as explicitly as technical and economic feasibility, both in proposed projects and in evaluations of ongoing experiments, a great deal would be added to the store of knowledge from the past in this area as well as from future experiments.

One reason for difficulties, however, may lie in measuring the energy demand of the poor as an abstract quantity. Needs as assessed by outside observation may not match the present or latent priorities of intended consumers. The attempt to obtain for planners a definition of energy and other demands by local populations themselves--if feasible--would provide a more helpful framework for considering supply alternatives. The most successful energy technologies introduced might then appear to be those requiring only marginal alterations in current practices and institutions; more efficient stoves that cook and look like traditional models may have more promise than solar cookers, for example.

On the other hand, some clearly advantageous energy sources--such as electricity and kerosene--appear to have had little difficulty in gaining acceptance where they have been affordable, even though they required radical changes in behavior initially. The factors involved in the adoption of these new technologies should be investigated.

Existing income distributions and ownership patterns clearly influence the benefits to the poor of new energy systems, first because even investments that are "economic" in the long-term may not be affordable to the poor, and second because new energy sources, like other resources such as capital and land, are likely to be more easily taken up and controlled by the relatively wealthy. More careful attention needs to be paid to mechanisms such as low cost, credit, or subsidies that would allow more of the poor to benefit from the introduction of new energy sources, particularly where a formerly "free" good becomes priced as a result. While the poor will always have less access to resources than others simply because they are poor, it is worthwhile to find out whether some energy systems may be inherently inimical or beneficial to distributional equity, or whether they are vulnerable to local controls in the same ways as other resources.

[Extracted from Chapter IV, Household Energy and the Poor in the Third World. Research Paper R-15, Resources for the Future, Washington, D.C. Copyright© Resources for the Future, 1979.]

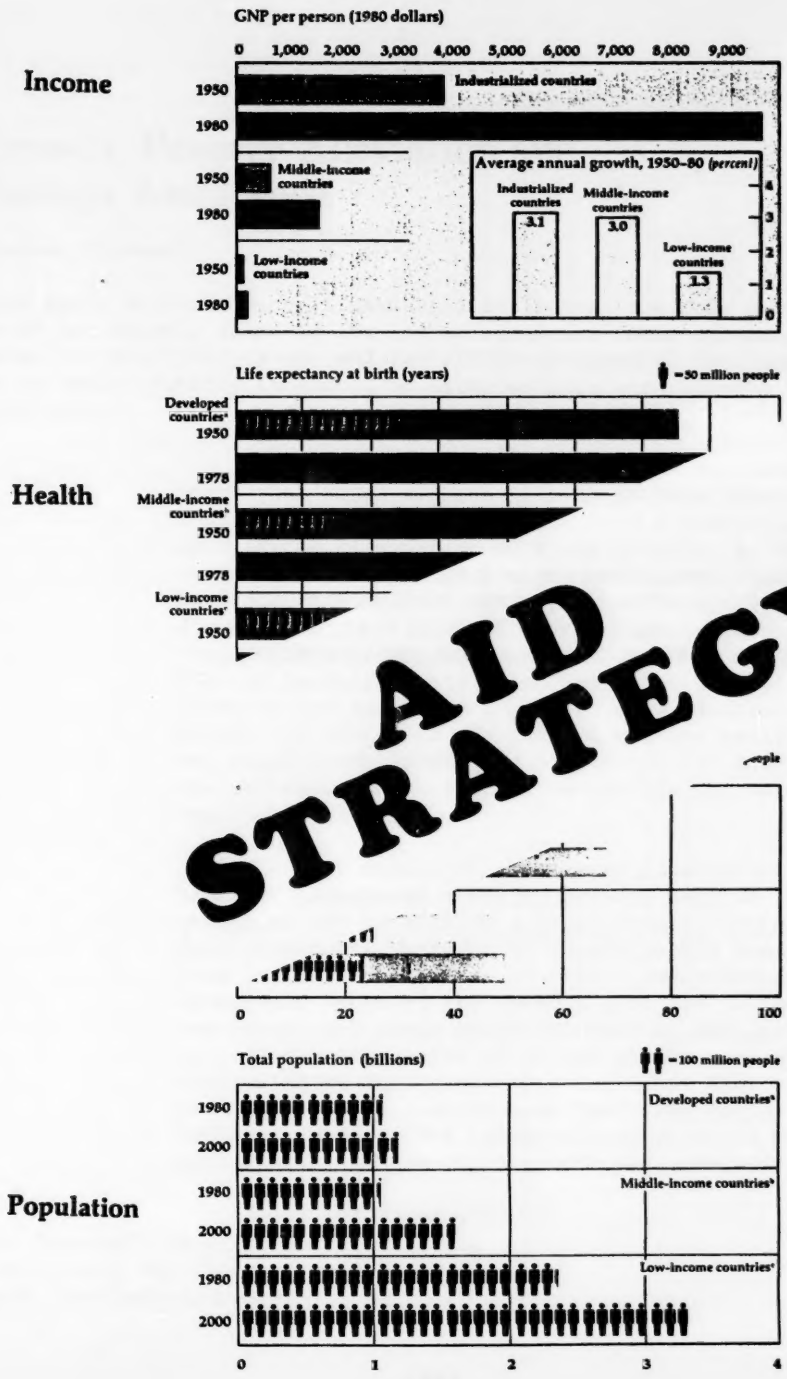
GNP per person (1980 dollars)
0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 9,000
Income
1950
1980
Industrialized countries
Middle-income countries
Low-income countries
Average annual growth, 1950–80 (percent)
Industrialized countries
3.1
Middle-income countries
3.0
Low-income countries
1.3
Life expectancy at birth (years)
= 50 million people
Developed countries
Health
Middle-income countries
Low-income countries
AID STRATEGY
0 20 40 60 80 100
Total population (billions)
= 100 million people
Developed countries
Middle-income countries
Low-income countries
Population
0 1 2 3 4

ILLUSTRATION OF SOME OF THE ELEMENTS
SUCH AS INCOMES, LIFE EXPECTANCY
AND POPULATION SIZE THAT NEED
TO BE CONSIDERED IN AID STRATEGIES.

Growth, Poverty Alleviation and Foreign Assistance

Michael Crosswell

[The basic argument made in this article is that the poor people of world are chiefly found in low-income countries where economic growth rates are relatively slow, and that if the purpose of development aid is to combat poverty it should be directed more consistently to such countries.]

Most of the literature on basic human needs asserts that rapid economic growth in less developed countries (LDCs) has failed to make a substantial impact in the alleviation of their poverty, in the enhanced satisfaction of basic needs of the whole population. This failure has typically been attributed to disequalizing patterns of growth within countries; these have allegedly generated a worsened distribution of income, little or no increase in absolute incomes of the poor, and a pattern of production and supply ill suited to the task of meeting basic needs. The basic needs literature has called for changes in the patterns of development to provide for more "equitable growth."

The main thesis of this paper is that the persistence of widespread absolute poverty despite rapid growth of GNP in LDCs as a group results not so much from inadequate patterns of growth within countries as from the uneven patterns of growth among developing countries. Most of the world's poor are in low-income countries; and these countries have by and large experienced very slow rates of growth as compared with the middle-income countries. Further, what data exist on trends in income distribution over time reveal no predominant tendency for income distribution to worsen with growth. Where rapid growth has occurred, it has

Mr. Crosswell is an economist with the U.S. Agency for International Development, Washington, D.C.

almost always resulted in a reduced incidence of poverty. This certainly does not mean that the current emphasis on basic human needs is misplaced; the development community faces a pressing need to alleviate world poverty. Nor does it imply that intra-country patterns of growth are unimportant. It does, however, point to a dimension of the basic needs problem that has been relatively neglected, particularly by aid donors. For it turns out that, while most of the developing world's poverty problem is heavily concentrated in low-income countries, the bulk of concessional foreign assistance has been directed primarily toward those in the middle-income range.

The first section of this paper takes up an analysis of the distribution of poverty among groups of countries, classified according to per capita income. The main findings are that over 80 percent of the world's poor are in low-income countries--those with per capita incomes in 1977 at or below $300; about half of the population in this group is poor. Countries with per capita incomes above $450 account for less than 10 percent of LDC poor, and the incidence of poverty in this group is only about 14 percent. The next section of the paper examines critically the proposition that rapid growth has failed to make a substantial impact on absolute poverty because of adverse trends in income distribution as growth proceeds. While cross-section data lend some support to this latter proposition, time-series data do not. Empirical studies of a number of developing countries suggest that rapid growth has typically been associated with reductions in absolute poverty.

The third section of the paper draws implications for donors of concessional foreign assistance. An examination of the distribution of Official Development Assistance (ODA) among groups of countries reveals that the low-income countries--with over 80 percent of LDC poor and over 60 percent of the total LDC population--received less than 45 percent of ODA commitments. In contrast the group of countries with per capita incomes above $450--which account for less than 10 percent of the poor and about one-quarter of the total population--received over 35 percent of ODA commitments. These results lead to a discussion of allocation models that donors might use to effect a redistribution of ODA along patterns that would be more consistent with the objective of achieving substantial reductions in LDC poverty by the end of the century. The final section of the paper reviews some of the evidence on the relationship between foreign assistance and growth. Although this evidence is mixed, it suggests that increased foreign assistance to low-income countries could make a substantial contribution to more rapid growth over the next ten to twenty years.

I. The Distribution of Poverty Among Countries

Estimates for 36 developing countries. The methodology used here for determining the distribution of poverty among countries is based

on the work of Ahluwalia, Carter and Chenery (Journal of Development Economics, September 1979). They in turn used as a point of departure estimates of real GDP per capita published by Kravis, Heston, and Summers (The Economic Journal, June 1978). The Kravis paper is motivated by the observation that the purchasing power of a dollar varies considerably from country to country at any given time. Accordingly, a comparison between two countries in terms of per capita income measured in dollars using conventional exchange rates does not give an accurate picture of one country's average real income relative to another's, nor of where a poverty line defined in dollar values would fall. The Kravis estimates of real GDP per capita represent an effort to deal with these disparities using an *exchange rate deviation index* that measures the extent to which nominal comparisons with income in the United States misstate real comparisons. For instance, the observed Kravis index value for India is 3.34, indicating (roughly) that a dollar in India in 1970 could purchase the equivalent of $3.34 in the United States in the same year. The deviation index values for 1970 range from 1.22 for Germany up to the 3.34 Indian value.

Ahluwalia, Carter and Chenery (abbreviated to ACC) used these Kravis adjustments in estimating percentages of population in absolute poverty for thirty-six developing countries. They started with 1970 per capita GDP figures in nominal terms measured in dollars on the basis of conventional foreign exchange rates, and converted these to dollars of uniform purchasing power (ICP dollars) using the Kravis index values. Thus, for Indonesia, real per capita GDP in ICP dollars was 3.10 times the level of nominal GDP per capita. ACC then posit a poverty line of 200 ICP dollars, which is about the income level of the 46th percentile of income recipients in India. This income level would be approximately adequate to ensure a daily supply of 2,250 calories in India. This poverty line is essentially a South Asian standard, which is conservative in the sense of yielding estimates that understate the extent of the poverty problem by standards that might be appropriate for more affluent developing countries.

Given this poverty line and the estimates of real per capita income (in ICP dollars), ACC use information on income distribution to estimate the percentage of population in absolute poverty for the other thirty-five developing countries. Their sample size was limited by availability of income distribution data, but the sample accounts for about 80 percent of developing country populations (excluding China). The ACC estimates of poverty incidence using purchasing power adjustments range from over 60 percent poor in Bangladesh, Ethiopia and Burma, down to under 10 percent in Taiwan, Argentina, Yugoslavia and Venezuela.

Estimates for 68 other developing countries. The next task is to estimate the incidence of poverty for some sixty-eight other countries for which reliable information on income distribution was not available. The basis for the estimates is the following regression equa-

tion, which was calculated using the ACC results for 36 countries just described.

(1) $$PPK = 75.70 - .094(PCIK) + .000030\ (PCIK)^2$$

t-values (18.58) (- 10.32) (7.33)

$R^2 = .85$

PPK = Percentage of population in Poverty, using Kravis adjustment of money values.

PCIK = Per Capita Income, with Kravis adjustment.

This equation indicates that most of the variation (85%) in percentages of population in absolute poverty (PPK) as estimated by ACC can be largely explained by levels of per capita income adjusted for purchasing power (PCIK). The missing information, of course, is the distribution of income. Surprisingly, including a single income distribution variable--the estimated share in total national income of the lowest 40 percent of income recipients (YD)--improves the explanatory power of the equation only slightly ($R^2 = .87$), and alters the value of each of the other coefficients by only about 8 percent.

The inclusion of the squared term $(PCIK)^2$ allows for the possibility that the effect of increases in real per capita income on the incidence of poverty becomes weaker as the percentage of the population in poverty declines. This makes sense, considering that an increase of $100 in per capita income would have a major effect on poverty in a very low-income country such as Ethiopia, where two-thirds of the people are poor, which it would not have in richer countries with smaller percentages.

The distribution of poverty among countries. Table 1 presents data on groups of countries determined by their 1977 per capita GNP, giving the percentages of poverty within each income group and the portion of total poverty accounted for by each group. The most striking result of this grouping of countries is the high concentration of total poverty in the poorer countries of the sample. About one-half of the countries in the sample have per capita incomes at or below $450; collectively they account for over 90 percent of total poverty in the sample. The bulk of this poverty is in countries with per capita income at or below $300, and a sizable portion is in India alone. This concentration of LDC poverty reflects not only low average levels of income, but also the fact that countries at or below $300 comprise over 60 percent of the total population under consideration. The second important feature of the data is the fairly steady decline in incidence of poverty as per capita income increases (second column).

Table 1: THE DISTRIBUTION OF POVERTY AMONG INCOME-LEVEL GROUPS OF DEVELOPING COUNTRIES

Country Group: 1977 Per Capita GNP	1977 Population (millions)	% Poor	Poor Population (millions)	Percent of Total Poor
Less than $150 (14 countries)	219.1	62	135.8	17.4
India - $150 (1 country)	631.7	46	290.6	37.2
$150 - $300 (24 countries)	401.3	51	203.6	26.1
$301 - $450 (13 countries)	245.9	31	76.6	9.8
$451 - $1200 (28 countries)	326.4	15	49.0	6.2
$1201 - $4800 (22 countries)	208.5	12	24.9	3.2
Total (102 countries)	2032.9	38	780.6	99.9

SOURCE: Country groupings are based on 1977 per capita GNP figures from the World Development Report 1979, or in a few cases from the 1979 World Bank Atlas. Population figures are from the 1979 World Bank Atlas.

II. Relationships of Economic Growth to Poverty Alleviation

Much of the discussion of basic needs has been motivated by a perception that economic growth has failed--that significant increases in GNP have not resulted in substantial reductions in world poverty. For instance, the World Bank/Sussex volume, Redistribution With Growth (Chenery et al., editors, Oxford University Press, 1974) was introduced with the statement: "It is now clear that more than a decade of rapid growth in underdeveloped countries has been of little or no benefit to perhaps a third of their population," (p. iii). In part, this view stems from the aggregate data on LDC performance, which demonstrate rapid growth in LDCs as a group but only slow progress in reducing poverty. Between 1960 and 1976, per capita GNP in developing countries grew at an average annual rate of 3.7 percent. At the same time the ILO estimates that between 1963 and 1972 the number of seriously poor in LDCs increased from 1.1 to 1.2 billion,

and the incidence of poverty fell only slightly, from 73 percent of LDC populations to 67 percent.

The bulk of the analysis of the evident failure of LDC growth to alleviate LDC poverty has attributed this failure mainly to patterns of growth *within* countries. These patterns are inferred from the tendency for the distribution of income to become more unequal as one moves from low to middle income countries, so that the impact of per capita income growth on the poor has been assumed to be either negative or at best only weakly positive.

With attention focused on growth patterns within countries, there has been relative neglect until recently of the pattern of growth *among* countries as perhaps the key factor underlying the slow pace of poverty alleviation. Yet the following data on growth rates of per capita income for LDCs grouped by income level, in conjunction with the estimates of the distribution of LDC poverty presented earlier, suggest that arguments about the failure of rapid growth to alleviate poverty need to be carefully examined. Table 2 indicates that in the group of countries where most of the world's poor subsist--the low-income countries--economic growth has on average been very slow. In contrast, middle-income countries, where both the incidence and numbers of poor are relatively low, have been growing rapidly. If anything, these data point to the success rather than failure of rapid growth in alleviating poverty.

Table 2: GROWTH AND POVERTY

Country Group	Average Per Capital Income Level ($)	Incidence of Poverty (%)	Share of LDC Poverty (%)	Average Annual Per Capita GDP Growth (%)	
				1960-70	1970-77
Low-Income	170	50	81	1.5	0.9
Middle-Income	1,140	19	19	3.7	3.5

SOURCE: World Development Report 1979 for data on income levels and growth rates. "Low-income" refers to countries at or below $300 (1977 prices). Averages are weighted averages.

Other evidence of the impact of growth on poverty alleviation. We now proceed to examine other kinds of data that shed a different light on the relations between growth and poverty. We begin with the data on per capita income, the income share of the lowest 40 percent, and estimates of the incidence of poverty derived by Ahluwalia, Carter and Chenery in the study presented earlier. The regression equa-

tion cited above indicated that, for the sample as a whole, 85% of the variation in poverty incidence could be explained by differences in the level of real per capita income. Our concern at this point is mainly with the effect of growth on poverty in the low-income countries in particular. Therefore, the following equation was tested for the 25 lowest income countries of the ACC sample, using data on 1975 per capita income (PCI) measured in 1970 prices and at official exchange rates, and on income shares of the lowest 40 percent of income recipients (YD).

(2) $$\text{Log PPK} = 14.80 - 1.43 \text{ Log PCI} - 1.53 \text{ Log YD}$$

t-values (20.47) (-20.30) (-9.05)

$R^2 = .95$

PPK = Percentage of population who are below the Poverty line, with Kravis adjustment.

PCI = Per Capita Income (not adjusted)

YD = Percentage of total income received by the poorest 40% of the population.

As the variables are all incorporated in logarithmic form, the coefficients are equivalent to elasticities: this equation indicates that an increase of 1 percent in per capita income will reduce the incidence of poverty by 1.43 percent (not percentage points) if income distribution remains unchanged. Consider a country with a per capita income of $100 (1970 prices), in which 15 percent of income accrues to the lowest 40 percent of recipients. If per capita income increases at constant prices to $110, the incidence of poverty would tend to decline from 58.6 to 51.1 percent. With a doubling of per capita income, the incidence of poverty would fall below 22 percent, as long as the income share of the lowest 40 percent remained unchanged. This equation explains 95 percent of the variation in the sample.

The regression results also reveal the importance of variations in income distribution as represented by the share of the lowest 40 percent of income recipients (YD). For instance, at a per capita income level of $100 the percentage in poverty will be about 58.6 percent with an income share of 15 percent, but will rise to 73 percent if this share falls to 13. The effect on the incidence of poverty of doubling of per capita income from $100 to $200 would be completely nullified if the share of the lowest 40 percent fell from 15 to 7.8 percent.

What changes in income distribution can one reasonably expect to accompany growth? Ahluwalia's investigation of the "Kuznets Curve" (M. S. Ahluwahlia, Journal of Development Economics, September 1976; see also Development Digest, April 1978, illustration p. 101 and

article pp. 103-124) suggests that the income share of the lowest 40 percent tends to decline sharply as one moves from the low-income countries to the middle-income countries. However, this tendency is not very consistent for his sample of forty developing countries; his regression equation explains only about 25% of the observed variation in the share of the lowest 40 percent. So other factors are also influencing this share, and they may counteract or even reverse the tendency to decline. Indeed, much of the discussion of the basic needs approach is explicitly directed towards finding patterns of growth that would lead to an improved (i.e., more equal) distribution of income.

Ahluwalia's estimates have been criticized for their exclusive reliance on cross-country observations (that is, comparisons among single year values from different countries). New evidence on trends in income distribution over time, rather than across countries, casts doubt on the proposition that distribution tends to worsen with growth in per capita income up to a point (to a middle income level), and then to improve, that is, to become more equal as incomes rise to higher levels. Gary Fields has investigated the experience of thirteen countries for which data on changes in income distribution over time appear to be reliable (Poverty, Inequality and Development, Cambridge University Press, 1980). His findings indicate that inequality, measured by the Gini coefficient, rose in seven countries (Argentina, Bangladesh, Brazil, El Salvador, Mexico, the Philippines and Puerto Rico) but declined in five (Costa Rica, Pakistan, Singapore, Sri Lanka and Taiwan) and probably declined in India as well. Fields concludes that no general relationship between changing inequality on the one hand and either initial level of inequality, level of GNP, or its rate of growth on the other has been found.

The study by Ahluwalia, Carter, and Chenery noted earlier also contains time series data on income distribution for a group of twelve countries. The ACC data indicate that in four countries there were substantial improvements in the income share of the lowest 60 percent; (Sri Lanka, Costa Rica, Colombia and Turkey); in five countries the share changed very little; (negligible changes in Yugoslavia, the Philippines, and Peru; a slight improvement in Taiwan and a slight decline in Korea); and in three countries there was a significant decline (India, Mexico, and Brazil).

To evaluate the Kuznets Curve hypothesis, we may look at per capita income levels of the eighteen countries covered by the two studies during the periods over which the time trends in income distribution were observed. We will take as a mid-point around which the curve changes direction the per capita income level of $670 in 1977 prices. For countries with relatively low incomes (below $670) over the period in question, income distribution should have worsened with growth. This occurred in El Salvador; but in other low-income coun-

tries, income distribution improved (Sri Lanka, Pakistan), or remained unchanged (Peru) with growth. In other cases the evidence on income distribution was mixed (India, Philippines); or growth did not take place (Bangladesh, where per capita income declined). In high-income countries (above $670), income distribution should have improved with growth. This occurred in three cases (Costa Rica, Singapore, and Turkey); but in four cases income distribution worsened (Brazil, Mexico, Argentina, Puerto Rico) or was substantially unchanged (Yugoslavia). Finally, there were three countries (Korea, Taiwan, Colombia) that moved from the low-income side of $670 to the high income side; income distribution improved in Colombia and did not change significantly in Korea and Taiwan. Taken together, these results do not support the proposition that income distribution tends to worsen with growth up to a point, and then improves as incomes rise further.

More positively, these findings give grounds for cautious optimism about the effects of trends in income distribution on the scope for alleviation of poverty, and indicate regional differences. LDC poverty is heavily concentrated in Asia, and secondarily in Africa. Of the five countries in which experience has been clearly that of positive growth combined with significant increases in inequality, all are in Latin America, and only one (El Salvador) would have fallen in the low-income group by 1977 standards. In contrast, the performance of the Asian countries is in some cases ambiguous or fairly neutral (Bangladesh, India, the Philippines, and Korea) and in other cases positive (Sri Lanka, Pakistan, Taiwan, and Singapore)--that is, income distribution became more equal with growth. For the low-income countries in this group (India, Pakistan, Sri Lanka, Bangladesh) as well as for Indonesia, the estimated share of the lowest 40 percent is relatively high. Unfortunately, the data for African countries are too scant to provide much information on that region.

While evidence on the relationship between growth and income distribution is somewhat ambiguous, the evidence on growth and poverty alleviation is more clear-cut. For virtually the same sample (with Thailand substituted for El Salvador), Fields finds ten cases where the percentages of the population in poverty decreased, and only three examples where poverty increased--India, Argentina and the Philippines. Since the average growth rates of per capita income were fairly low for both India and Argentina for the periods in question (1.2 percent and 1.4 percent), this hardly constitutes a failure of rapid growth.

In addition, a number of simulation studies that incorporate the assumption that income distribution will follow the path described by the Kuznets Curve also indicate that the incidence of poverty nonetheless declines substantially as per capita GNP increases. [Description of studies omitted from this extract.]

None of this is to deny the importance of the *pattern* of growth in terms of the distribution of increases in income and the composition of changes in output. Equation (2) above indicates that for low-income countries variations in the share of the lowest 40 percent of income recipients (YD) can have powerful effects on the incidence of poverty associated with a given income level. But the key point is that if rapid growth can be achieved in low-income countries, the effects in terms of poverty alleviation are likely to be substantial and positive even with some worsening of the income distribution. And if that worsening can be avoided, as past experience suggests that it can, so much the better.

III. The Distribution of Official Development Assistance Among Recipient Countries

The current distribution of aid flows. Official Development Assistance (ODA) is defined by the Development Assistance Committee (DAC) of the OECD as grants or loans undertaken by the public sector (including international agencies as well as national donors) that have as their main purpose the promotion of economic development and welfare, and that are offered at concessional terms (if a loan, at least 25 percent grant element). This concessional assistance comprises only a portion of total resource flows to developing countries. For instance, in 1976 ODA accounted for about 30 percent of total disbursements of medium- and long-term capital from industrialized to developing countries. (For the World Bank Group, lending by IDA of $2.86 billion in 1978 was counted as ODA, while IBRD lending of $6.55 billion was not.)

The data presented in Table 3 represent average annual commitments of ODA during the 1976-78 period from all sources except cen-

Table 3: THE DISTRIBUTION OF POVERTY AND OFFICIAL DEVELOPMENT ASSISTANCE, 1976-1978

Recipient Country Group: 1977 Per Capita GNP	Percent of Total Poor (%)	ODA Commitments ($ million per year)	Percent of Total ODA (%)
Less than $150	17.4	3,385	13.3
India - $150	37.2	2,100	8.3
$150 - $300	26.1	5,793	22.8
$301 - $450	9.8	4.979	19.6
$451 - $1,200	6.2	5,541	21.8
$1,200 - $4,800	3.2	3,605	14.2
Total	99.2	25,403	100.0

SOURCE: World Development Report 1979, (World Bank) and Development Cooperation 1980 (OECD).

trally planned economies. They include commitments by OECD countries, multilateral institutions, and countries belonging to OPEC. The data have been collected for 102 recipients who received at least $75 million each in ODA commitments over the three-year period. The countries collectively accounted on average for over $25 billion per year, nearly 90 percent of total ODA commitments reported by the DAC.

The data in Table 3 indicate that the low-income group (under $300) which accounts for 80 percent of the developing world's poor receives only 44 percent of concessional assistance, while countries accounting for less than 10 percent of the poor (over $450) receive 36 percent of concessional assistance. India alone accounts for a great deal of this disparity between the distribution of poverty and the distribution of ODA.

Explaining the allocation pattern. A number of studies in recent years have sought to explain allocation patterns of development assistance. Paul Isenman (1975) investigated flows of development assistance during the late 1960s and early 1970s from a variety of sources: USAID, DAC members as a group, the IBRD, IDA and the UN Development Programme. His results strongly confirmed two "biases" in aid allocations: a middle-income bias, revealed in the tendency for per capita assistance to rise as per capita income increases to a level of $400 (in 1970 prices, equivalent to about $650 in 1977 prices), and then to fall; and a country-size bias, reflected in the tendency for per capita assistance to be lower the larger the population of the recipient. Edelman and Chenery (1977) used aggregate data on commitments of "Official Concessional Assistance" (i.e., ODA plus multilateral loan commitments that are not sufficiently concessional to qualify as ODA) from OECD countries, international organizations, and OPEC to a sample of 89 countries. Their tests confirmed both the country-size and middle-income biases (although the middle-income bias for the 1970-72 period was not statistically significant). Dudley and Montmarquette (1976) tested 1970 commitments from various bilateral donors, for recipient population, per capita income, political ties to the donor in question, economic ties to that donor, and "bandwagon" effects (the tendency for a donor to give more aid to countries receiving substantial amounts of aid from other sources). Their results indicated an insignificant role for population size in explaining aid allocations of most donors once political, economic and bandwagon factors were taken into account.

Are the middle-income and country-size biases still reflected in more recent allocations of assistance? To gain some perspective on this question, I tested the following equation for 1976-78 assistance for a sample of 101 developing countries.

The explanatory power of the equation is fairly high (69%). The population coefficient is clearly significant and evidences a very strong bias against large countries. This accounts for much of the

(3) Log PCA = 10.38 - .73 Log Pop - 1.89 Log PCY + .147 (Log PCY)^2

t-values (3.2) (13.0) (-1.8) (1.8)

R^2 = .69

PCA = Per Capita Assistance 1976-78.

Pop = Population.

PCY = Per Capita Income in 1977.

concentration of assistance in middle-income countries, which on average have smaller populations than the low-income countries, even when India is excluded from the latter group. The per capita income coefficients indicate a *reversal* of the middle-income bias, i.e., a tendency for per capita assistance to *fall* as per capita income *increases* to about $620 and then to rise; but these trends were not highly significant statistically.

Before concluding that the behavior of donors has changed, several factors need to be mentioned that make it difficult to compare these results with those of Chenery/Edelman and Isenman. The former included "hard" loans from multilateral banks that were not sufficiently concessional to qualify as ODA and which were excluded from my figures; most of these funds go to middle-income countries. Secondly, my sample of countries includes a number of very small, high-income recipients of ODA not included in either of the other two studies. This, too, had an effect on the assistance-income relationships.

While the equations tested omit political variables, it is obvious that these play an important role in the allocation pattern. For instance, the four largest deviations of actual from predicted allocation levels are accounted for by Egypt, Israel, Jordan, and Syria, which together claimed over $6 billion in annual ODA commitments, almost 25 percent of the total.

Mechanisms for changing the allocation pattern. Questions about what factors explain the existing assistance allocations lead naturally to questions about how aid ought to be allocated, and in what directions. Both Isenman and Chenery/Edelman argue that the country-size bias ought to be softened if not eliminated, and that the bias towards middle-income countries ought to be converted to one towards the low-income countries. Several allocation models have been developed, aimed at explicitly addressing these biases.

Cline and Sargen propose an aid allocation model that determines allocations of development assistance according to need and performance criteria (World Development, June 1975). Their approach starts, as most donors would, with a specified amount of assistance and a list of potential recipients. They then seek a linear path such that *per capita assistance* declines as per capita income increases. Thus they incorporate an explicit bias in favor of low-income countries,

and remove any bias based on population size. By stipulating a ceiling level of per capita income at which assistance falls to zero, they can determine a unique linear relationship between per capita income and per capita assistance that will use up the exact amount of assistance available.

The next step is to incorporate country "performance" criteria, that are used to adjust in either direction the allocations determined by the need criterion alone--i.e., per capita income; this measure implicitly takes account of population size along with need. The factors that are taken into account in performance include a high savings rate, high export growth, low inflation, high tax revenues, and efficiency in resource use as measured by a low incremental capital/output ratio. Two of these indicators--savings and tax revenues --are measured in terms of deviations from expected performance as predicted by per capita income. Thus, a low-income country's savings performance would be evaluated relative to the savings rate expected of an average low-income country, rather than in comparison to the higher savings performance of middle-income countries. Each indicator is normalized by dividing by the respective standard deviation. For each country the five indicators are aggregated into a single composite performance indicator, using an arbitrary weighting scheme. This indicator is then used to adjust per capita allocations upward for high performance or downward for performance below average. A broadly similar allocation model [described more fully in the original] has been developed at AID and used to arrive at preliminary indicative levels of development assistance for medium-term planning purposes. (The model is developed in Michael Crosswell, "Basic Human Needs and the Distribution of Development Assistance Among Countries: The Indicative Planning Allocation Procedure," AID Mimeo, August 1979.)

IV. Foreign Assistance and Growth

Empirical evidence that aid contributes to growth. The discussion so far has pointed to a concentration of the LDC poverty problem in low-income countries, and a concentration of concessional foreign assistance in middle-income countries. Given a concern with poverty alleviation, the argument for an increase in concessional assistance to low-income countries rests on two propositions: that growth can be effective in alleviating poverty in these countries, and that increased foreign assistance can make a significant contribution to growth. We now turn to this latter proposition.

The main evidence against the argument that increased assistance accelerates growth rests on the finding that foreign capital inflows and domestic savings rates are inversely correlated. Weisskopf estimated that "approximately 23 percent of net foreign capital in-

flow substitutes for domestic savings" (Journal of International Economics, Vol. 2, No. 1, 1972, p. 37). Other authors have found similar negative correlations.

Papanek provides a review and criticism of this literature that accepts the observed negative correlation between foreign inflows and domestic savings, but sets forth several arguments against a conclusion that foreign assistance causes savings efforts to decline (The Economic Journal, Vol. 82, No. 327, 1972). One argument is that some foreign assistance is explicitly directed towards activities commonly classified as consumption rather than investment--emergency food aid; military assistance; recurrent cost financing of some government services such as health, education and agricultural inputs; and so forth. Yet insofar as it is provided as a grant, it has no bearing on domestic savings effort. A second argument rests on the tendency for assistance to rise in times of crisis caused by exogenous factors such as war, weather, or adverse movements in the terms of trade; in these situations, savings are likely to fall more sharply than income, which would produce an observed negative relationship between foreign assistance and savings rates, again without reflecting causality from increased aid to diminished savings effort. Papanek concludes that "As long as both savings and foreign inflows are substantially affected by third factors, the negative correlation between the two found in many studies sheds little or no light on their causal relationship," (op. cit. p. 950).

Even if a dollar of foreign assistance increases investment by somewhat less than a dollar, the effects on growth can nonetheless be positive and substantial. In a subsequent paper (Journal of Political Economy, Vol. 81, No. 1, 1973), Papanek tests the effects of domestic savings, foreign assistance, private foreign investment, and other foreign flows (short term capital)--all measured as ratios to GDP--on growth of GDP. The samples tested include a group of thirty-one Asian countries, and a larger group of eighty-five developing countries:

		Savings		Aid		Foreign Investment		Other Flows	R^2
Growth =	1.5	+ .20	+	.39	+	.17	+	.19	.37
(n=85)	(2.5)	(6.0)		(5.8)		(2.5)		(2.1)	
Growth =	1.5	+ .21	+	.46	+	.35	+	.13	.46
(n=31)	(1.5)	(5.0)		(4.4)		(1.7)		(0.8)	

(T values in parentheses)

The various sources of investment collectively explain a fairly substantial portion of observed growth performance. Particularly noteworthy are the relatively high coefficients for aid, which appear to

have a more significant effect on growth than either domestic savings or other forms of foreign resource flows. However, these may be somewhat exaggerated; the validity of these coefficients for aid depends on whether aid is correlated with other sources of growth not included in the equation. If aid flows disproportionately to countries that make better use of resources, for example, then the coefficients for aid in Papanek's results would be overstated (unless it was aid which caused the higher efficiencies).

The most prevalent analytical framework for relating flows of foreign assistance to growth in GNP is the two-gap model (Chenery and Strout, American Economic Review, Vol. 56, No. 4, 1966). Chenery and Strout used this model to formulate projections of growth and foreign assistance requirements over the 1962-75 period for fifty developing countries. Chenery and Carter provided an interim review of development performance relative to these projections for the period up to 1970. Lewis and Michalopoulos (unpublished AID paper, January 1980) have recently looked at the Chenery/Strout and other projections of developing country performance through 1975. These reviews provide some insights into the contribution of foreign assistance to more rapid growth.

Chenery and Carter (American Economic Review, May 1973) note that growth over the sixties was on the whole fairly close to the projections in their model. Of thirty-seven countries, twenty-five were within 1.2 percentage points of projected rates, five grew substantially more rapidly, and seven grew much more slowly. Overall there was a considerable shortfall in foreign capital inflows; however, export performance was much better than projected. Of five countries where growth was high: the foreign capital inflow was of major significance in explaining the surprisingly good performance in Kenya and Thailand; of less significance in Korea; and unimportant in Iran and Taiwan. For 13 low-growth countries, only four received amounts of assistance even close to their projected needs. Of course, the causality between poor performance and low aid levels can run both ways. Chenery and Carter single out India as an important case where shortfalls in foreign assistance severely constrained growth; they argue that, based on India's savings and export performance, aid allocated to India on a basis comparable to other countries would have raised the annual growth rate from 3.5 to 5.8 percent.

The review by Lewis and Michalopoulos for the 1960-75 period provides an analysis by region that compares the foreign capital inflow in 1975 with the level projected by Chenery and Strout. For South Asia, the projections called for $8.1 billion, whereas the actual foreign capital inflow was $2.6 billion. There was a corresponding shortfall in the growth rate of investment over the period (4.6 percent actual versus 7.9 percent projected) and of output (3.8 percent

versus 6.1 percent projected). For sub-Saharan Africa the foreign capital inflow in 1975 exceeded the projections ($5.4 billion versus $3.7 billion) but investment growth fell well short (5.8 percent versus 7.3 percent projected). Nonetheless, the GNP growth rate was close to what was projected (4.4 percent versus 4.8 percent projected). Insofar as large amounts of aid were used in Africa for relief of drought and famine during the first half of the 1970s, this may explain the low savings and investment growth.

The evidence presented by these studies on the importance of foreign assistance in achieving accelerated growth is ambiguous, in part because the experience of various countries and regions was mixed, and in part because there is not a clearly valid methodology for identifying the contribution of increased foreign assistance to accelerated growth, or the lack of foreign assistance to slow growth. For our purposes, the most important point concerns the experience of South Asia in general and India in particular, insofar as both papers suggest that nonavailability of foreign capital severely constrained investment and growth in the region where most of the world's poverty is concentrated. [Discussion of evidence from simulation studies omitted here.]

Outlook for the 1980s. Since the bulk of this paper was written, the World Development Report, 1980 has been issued. Prospects for the low-income oil-importing countries--essentially the low-income countries discussed in this paper other than Indonesia, Angola and Zaire--are seen by the World Bank as quite dim in light of the 1979-80 increases in oil prices. Over the next decade, the average annual growth rate in per capita income for this group is projected to be somewhere between 1.1 and 2.0 percent. Growth at these rates will result in only very slow progress in reducing the high incidence of poverty in the group of countries that account for most of the world's poor, and quite possibly implies an increase in the absolute numbers of poor. The urgency of international measures to accelerate the flow of concessional assistance to low-income countries, as well as domestic policies to ensure that foreign assistance effectively contributes to their growth, has never been greater. In the absence of such measures, discussions of whether growth does or does not result in substantial reductions of poverty will be purely academic.

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EDITORIAL COMMENT: SOME TRENDS IN THINKING ABOUT DEVELOPMENT IN THE 1970s AS REFLECTED IN THE DEVELOPMENT DIGEST

Gordon Donald

It is almost exactly a decade ago that Mahbub ul Haq of the World Bank, formerly Chief Economist of the National Planning Commission in Pakistan, spoke up at the 12th World Conference of the Society for International Development in Ottawa, Canada, with a critique of the theory and practice of development planning, of which he was a leading practitioner. He found that prevailing development policies, even successful ones, seemed to do little or nothing for the very poor people in countries like Pakistan, that governments hardly knew what was happening to their poor populations, and that economic theory provided too little guidance to effective remedies for poverty. He proposed "that we stand economic theory on its head and see if we get any better results." To many in the audience (including this editor) his speech seemed eloquent and thought-provoking, and it found its way into the Development Digest (see D.D. October 1971, p. 3).

This shift of attention toward the poor within developing countries has been one of the important themes in the evolution of development thinking in the 1970s, though not the only one. Two other kinds of shift in emphasis should be noted: increased attention to the development of agriculture and rural areas, which had tended to be neglected in favor of industry; and an increase in concern with employment as such, due to growing problems of underemployment. There is a relationship between these trends and the concern with poverty: the majority of the poorer people in most developing countries are working in agriculture, and in rural areas generally; and the poor are also the underemployed, urban or rural.

A focus on employment creation (see D.D. October 1969, pp. 3-48; January 1971, pp. 77-124; January 1972, pp. 87-124) leads into the technologies used in either agriculture or industry: if the most "modern" methods of production are capital-intensive they will use up limited supplies of capital faster, and create fewer jobs, than would use of a labor-intensive method. If wages are low enough the latter may also be the lowest in cost; but this does not necessarily follow, as there are other dimensions to the problems of efficiency (explored in D.D. October 1976, pp. 69-124). The use of "intermediate technology" does not take care of all such efficiency problems; each case must be considered individually. At the same time there is a gener-

Dr. Donald is editor of the Development Digest.

alized situation referred to as "dualism": high technology (eating up capital) and high incomes in a small modern sector, contrasting with a (capital-starved) traditional sector of low-productivity low-income activities in the rest of the economy. Much of the effort to deal with underemployment consists in combating trends that seem to cause this dualistic condition to persevere and intensify. Many of the proposed counter-measures remain somewhat controversial, however, since they upset political and economic interests in existing industries, and since higher labor intensity can be portrayed as "backward."

Along with the critique of capital-intensive technology there has been a growing interest in the development of rural areas. With agriculture as the central activity rural growth requires increasing farm production, which implies improved crops and methods obtained by increasing extension services, credit, marketing, etc. But here too, as in the cities, there is a problem of dualism: conventional extension, credit and marketing institutions seem better adapted to larger farmers than to small ones. Accordingly, small farmer problems have been getting increased attention (D.D. January 1974, pp. 47-64; October 1974, pp. 55-80; July 1978, pp. 3-50). Also involved in the new rural emphasis are non-farm activities like rural industries, public services and public works (e.g., D.D. October 1973, pp. 41-80). Beyond that, the landless rural poor, usually the most disadvantaged and neglected element, are becoming of interest to some groups (D.D. January 1979, pp. 3-26). Aid donors have devoted increasing sums of money to integrated rural development programs, including innovative pilot projects along with conventional agricultural projects. Some of the newer approaches have encountered problems different from those in conventional projects, and the attempt to develop theory on how best to mobilize rural people and resources has been pursued (D.D. July 1975, pp. 3-46). At least one economist has outlined a sophisticated rural-led development strategy (John Mellor in D.D. January 1977, pp. 3-31) as against the more usual industry-led approach.

At a more general level, there has also been a questioning of the basic purposes of development, and of the ways in which developmental progress is measured. The conventional ideas on purposes of development have been assumed to center around national economic growth--growth in the production of all kinds of goods and services, conventionally measured by GNP (gross national product) per person in a national population. But the per capita GNP measure has come under attack, not only as being a lot less precise than it pretends, but as unsuitable because it does not focus on progress for the poor (see D.D. January 1973, pp. 75-90 for two sides of this question). Alternative measures of developmental progress have been proposed (D.D. January 1980, pp. 75-124). The most widely espoused of the

poverty-oriented alternatives has been that of meeting the "basic needs" of a people (D.D. January 1977, p. 32, and January 1978, p. 119; on policy implications see also D.D. July 1979, p. 55). Progress could be measured not by overall economic growth regardless of who benefited and how much, but rather by the extent to which the basic needs of an entire population for adequate food, shelter and clothing were being met. The list of such basics is usually extended to health care facilities and primary education, and sometimes the concept of "participation" in decision-making or some related idea is included.

In some quarters the questioning of economic growth as a goal was carried to a more radical attack on growth as such, based on a concern for what it was doing to the world's environment--that is, its allegedly destroying the physical base on which we all depend. The "limits to growth" were heatedly debated in the early 1970s (see D.D. October 1974, pp. 3-52 for pros and cons). The major thrust of the environmental movement, however, has not been in an anti-growth direction so much as in efforts to modify developmental activities in order to preserve or enhance the environment and therefore the growth potential of the future (D.D. January 1971, pp. 3-42; April 1972, pp. 3-42; January 1975, pp. 107-124). For the most part, intellectuals in the developing countries have resisted the extremes of the limits-to-growth proponents, feeling that their own countries had not yet had their growth opportunities--a consideration that may have made some people unduly wary of the environmentalists' arguments in more limited spheres.

Even if the notion of clear-cut growth limitation is rejected, the emphasis on combating poverty does in some degree restrain the enthusiasm for growth if it is thought that there is a necessary trade-off, or choice, between them--that is, if a focus on improvement among the lowest income receivers can only be achieved at the cost of at least some slow-down in national economic growth rates. In the later 1970s attention turned toward a search for ways to obtain greater "equity," a greater equality in national income distribution (D.D. July 1978, pp. 95-124, and October 1978, pp. 99-124; on political aspects of the tolerance of inequality, see D.D. April 1974, p. 55). As the results of particular policies were examined, however, it became apparent that it is difficult to bend societies very rapidly toward greater income equality. Policies to spread employment more widely in industries, to raise rural incomes via rural investments and (as pertinent) land reforms, and others have tended to work out more slowly than many had expected. But in Cuba, where extreme revolutionary methods of equalization had been followed, the weakness of the growth record despite much foreign aid has pointed to a significant growth-equity trade-off.

Some of the thinking on trends in income inequality has suggested a kind of inevitability in the development process: it was thought that low-income countries would first have to go through a process in which the poor would be left behind other groups in society while the economy created new enclaves of superior wealth and technology; at a later stage of growth, the developmental benefits would begin to spread more widely after a period of learning and consolidation. Indeed, this kind of process is discernible in the history of earlier stages of development in Western Europe, and analogous processes are discernible in Eastern Europe and the U.S.S.R. as well. Such a process has been inferred for the presently poor countries by reference to the "Kuznets curve", on which the greatest inequalities are found among the countries at a middle income level.

This brings us to the preceding article by Michael Crosswell, in which the author argues that more recent data collection has failed to support the inevitability thesis. Low-income countries have not moved consistently toward greater inequality in income as they advanced up the development ladder with increasing per capita GNP: some did follow this path, but equal or greater numbers did not. In any case, too little is yet known about these shifts in the majority of developing countries to assert the inevitability of the path leading through greater inequality. And, clearly, there are countries which have made a success of growth and equity together--which does not mean that every nation could do the same, but it indicates that the possibilities are not predetermined and foreclosed. Crosswell's article implies a faith in economic growth in low-income countries as the basic element in any war on global poverty--not the only element, of course, but one that we cannot do without.

Have we returned to the point where we were before these debates of the 1970s began? Such a conclusion does not follow, since much has been learned from experience in the interim about how more rapid and sustainable growth can be achieved, about how a variety of variables affect different income groups, as well as about other aspects of development such as technological choices, environmental impacts, and others. We cannot but be wiser today, even if much remains to be learned or investigated more fully. There remain differences in values, in what different people may want for their country's future. Some may want faster progress toward modernity as they interpret it, which may include military and political power; others may lay stress on meeting basic needs; some prefer centralism, others decentralized methods of governing. Technical experts and economists cannot tell people what they should want, but they can indicate some of the results of following various possible policies.

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